Proposed Final Draft Delta Science Plan

One Delta, One Science

October 15, 2013

PROPOSED FINAL DRAFT DELTA SCIENCE PLAN

This is the third draft of three versions of the Delta Science Plan presented to the Delta Stewardship Council (Council) in the following order:

June 2013: First Draft Delta Science Plan

August and September 2013: Second Draft Delta Science Plan

October 2013: Proposed Final Draft Delta Science Plan

At each stage of the development of the Delta Science Plan, the Delta Lead Scientist will publicly present the latest draft to the Council for the purpose of receiving information and comments from the Council and the public. All Council meetings are public and simulcast on the Council website at www.deltacouncil.ca.gov.

Preamble

The Delta of the Sacramento and San Joaquin rivers is the hub of California's extensive water supply system and critical to the State's economy. However, emerging scarcities of water in the Delta watersheds, which are expected to intensify with global warming, threaten California's ability to sustain further economic development and population growth. At the same time, patterns of water and land use have resulted in severe declines in the abundances of many valuable native species. Protecting and restoring these species while maintaining a reliable water supply and building California's economic future is an absolute priority. The economic and environmental stakes in the Delta are enormous. Over 27 million people rely on Delta water and the ecosystem has been degraded to the point where over 60 native species are listed as threatened or endangered. The Delta and its water supply infrastructure are also highly vulnerable to earthquakes, floods, and droughts. Proposed actions under the Bay Delta Conservation Plan to reduce risks to the people, ecosystems and economy of California are likely to cost many billions of dollars. The Delta Stewardship Council and the Delta Conservancy are dedicated to balancing water supply reliability with ecosystem recovery—the coequal goals. Achieving these goals will depend upon acquiring and communicating a new shared body of scientific knowledge to catalyze cultural change. The Delta Science Plan is intended to be that catalyst.

The Delta Science Plan provides direction for achieving an integrated, collaborative, and transparent science of the Delta to enhance policy and management decisions. The Plan is transformative and uses principles that have proven successful in other Big Science programs—embracing emerging technologies and fostering open science communities. The Science Plan uses collaboration to build trust and acquire a shared body of scientific knowledge. It proposes new mechanisms for synthesis and communication that will enhance decision-making and reduce conflicts that hinder policy decisions. Vigorous and sustained investment in the Delta Science Plan will ensure that the responsible agencies have the knowledge, trust, and collaboration necessary to achieve the coequal goals.

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Users and uses of the Delta Science Plan

Achieving the vision of *One Delta, One Science* requires a new culture of cooperation and stewardship among policymakers, scientists, managers, and interested public. This Plan provides a framework for science cooperation across authorities vested in multiple agencies and programs. To build this lasting community of cooperation, the following users and uses of this Plan include[1]:

Users	Uses
Delta Science Program	♦ Guide Delta Science Program activities including leading numerous Delta Science Plan actions (i.e., develop, update, and implement the Science Action Agenda) ♦ Obtain high-quality science to inform decision-making
Delta Stewardship Council	♦ Coordinate and support best available science, adaptive management, early consultation and consistency determinations for covered actions and inform oversight of scientific aspects of Delta implementation activities to achieve the coequal goals ♦ Support revisions to the Delta Plan, including potential changes to its regulations and their implementation
Science programs in the Delta (e.g., Interagency Ecological Program, Bay Delta Conservation Plan, State and Federal Contractors Water Agency Coordinated Science Program, Delta Regional Monitoring Program)	♦ Guide coordination and integration among programs to leverage science efforts and inform water and environmental decision-making ♦ Provide the context and shared approach for implementing priority science actions ♦ Integrate synthetic thinking into project and program activities ♦ Develop and implement science work plans tiered from the Science Action Agenda ♦ Support and utilize improvements to science infrastructure
Delta scientists	♦ Foster and enhance science networking and collaboration ♦ Integrate synthetic thinking into project and program activities ♦ Enhance connections with Delta policy and management communities
Delta managers (those implementing actions such as water operators, habitat restoration practitioners, levee engineers)	♦ Provide input on and support for priority science needs ♦ Identify the context for implementation approach and elements of the Delta Science Plan ♦ Obtain high-quality science to inform decision-making ♦ Utilize scientific conflict management mechanisms ♦ Enhance connections with Delta scientists
Delta policymakers	♦ Guide participation in the Policy-Science Forum and ensure science is targeted to support decisions ♦ Guide coordination and integration among programs for implementing the Delta Science Plan ♦ Obtain high-quality science to inform decision-making ♦ Enhance connections with Delta scientists ♦ Utilize scientific conflict management mechanisms

[1] Entities with primary responsibilities and participation roles are identified per action or suite of actions in the Delta Science Plan.

Users	**Uses**
Delta stakeholders (people and organizations who use, influence, and have an interest, or "stake," in the Delta and Delta science.	♦ Provide input on priority Delta science activities ♦ Engage with Delta scientists and science community activities ♦ Integrate stakeholder perspectives into science-based decision-making ♦ Enhance connections among Delta policy, management, stakeholder, and science communities
Interested public (including scientists, local agencies, and communities and individuals)	♦ Provide input on priority Delta science activities ♦ Engage with Delta scientists and science community activities ♦ Enhance connections among Delta policy, management, and science communities
Science Steering Committee	♦ Provide the charge to the Science Steering Committee ♦ Integrate synthetic thinking into project and program activities ♦ Enhance connections among Delta policy, management, and scientists
Delta Independent Science Board	♦ Inform oversight of scientific research, monitoring, and assessment of programs that support adaptive management of the Delta through periodic reviews of scientific research, monitoring, and assessment of programs at least once every four years (Water Code §85280(3)) ♦ Inform recommendations for strategic science planning and activities ♦ Obtain high-quality science to inform its oversight and review activities

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List of Acronyms

BDCP	Bay Delta Conservation Plan
CAMT	Collaborative Adaptive Management Team
CDFW	California Department of Fish and Wildlife
CSAMP	Collaborative Science and Adaptive Management Program
CVP	Central Valley Project
CWEMF	California Water and Environmental Modeling Forum
CWQMC	California Water Quality Monitoring Council
Delta ISB	Delta Independent Science Board
DRERIP	Delta Regional Ecosystem Restoration Implementation Plan
Delta RMP	Delta Regional Monitoring Program
DSC	Delta Stewardship Council
DSP	Delta Science Program
DWR	Department of Water Resources
ERP	Ecosystem Restoration Program
FRPA	Fish Restoration Program Agreement
IEP	Interagency Ecological Program
MAST	Management Analysis and Synthesis Team
NGO	Non-Governmental Organization
NMFS	National Marine Fisheries Service
NRC	National Research Council
OCAP	Operations Criteria and Plan
PSP	Proposal Solicitation Package
RFP	Request For Proposal
SRCSD	Sacramento Regional County Sanitation District
SBDS	*The State of Bay-Delta Science*
SFCWA	State and Federal Contractors Water Agency
SWP	State Water Project
SWRCB	State Water Resources Control Board
USBR	United States Bureau of Reclamation
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey

Executive Summary

Why a Delta Science Plan?

The California Delta is part of a complex and unique estuarine system that has been dramatically changed by human, land, and water uses in the past two centuries. It has become the hub of California's water supply infrastructure and is also central to many other recreational, industrial, and agricultural uses that are critical to the economic and cultural well-being of California. At the same time, it is widely recognized that the present Delta is a fragile system at great and constant risk of failure or major damage from floods, droughts, earthquakes, and further ecological collapse, to name just a few. The effects of continued human population growth and climate change are likely to increase these risks in the near future. Clearly, the risks are severe, and the urgency of taking decisive and comprehensive action to prevent them or at least lessen their impact cannot be overstated.

In 2009, the State passed legislation (Delta Reform Act) to take such action. The legislation included creation of the California Delta Stewardship Council and the Delta Independent Science Board (Delta ISB). The Council is tasked with completing and implementing a comprehensive Delta Plan. This Plan was completed in 2013. The 2009 legislation also established new requirements for the use of science in the development and implementation of all Delta policies and management – in essence, all actions need to be based on science. The Delta ISB is charged with reviewing the application of science and the effectiveness of science practices throughout the Delta. This key role of science was further underscored in a joint statement by California Governor Jerry Brown and U.S. Department of the Interior Secretary Ken Salazar in 2012, "*with science as our guide, we are taking a comprehensive approach to tackling California's water problems*.[2]"

But is Delta science up to the job? Does it effectively deliver the kind of highly credible, relevant, and legitimate information needed to turn science into effective actions that address today's challenges of large-scale, complex, interconnected, and constantly changing management issues? What needs to be done so science can reliably serve as the foundation for broadly accepted, durable solutions instead of merely documenting problems or even contributing to additional confusion, delayed action, and costly conflict that judges are asked to resolve in the courtroom?

In its review of the sustainability of water and environmental management in the California Bay-Delta, a committee of the National Research Council (NRC) found that "*only a synthetic, integrated, analytical approach to understanding the effects of suites of environmental factors (stressors) on the ecosystem and its components is likely to provide important insights that can lead to enhancement of the Delta and its species*" (NRC 2012, p. 49). While some examples of effective synthesis exist, this kind of approach is largely absent in the Delta at this time. This is especially true at the large, comprehensive scale, and with the long-term commitment needed to address the Delta's grand management challenges. The NRC Committee also emphasized that science alone is not the solution; science needs to be effectively

[2] From July 25, 2012 Governor Brown and Obama Administration joint announcement on the proposed path forward for the Bay Delta Conservation Plan and California's water future.

integrated with policy and management, and appropriately utilized to "*pave the way toward the next generation of solutions to California's chronic water problems*" (NRC 2012, p. 194). The NRC Committee found that in the Bay-Delta, a large science-action gap urgently needs bridging. The NRC Committee concluded that to bridge this gap, "*a collaborative effort is needed, where scientists and governance professionals work together as a single team, rather than as two separate entities*" (NRC 2012, p. 175). The Delta Stewardship Council acknowledged the NRC Committee's findings and recommendations in its 2013 Delta Plan and recommended that the Delta Science Program work with others to develop a comprehensive Delta Science Plan "to organize and integrate ongoing scientific research, monitoring, and learning about the Delta as it changes over time" (Delta Stewardship Council 2013). Others also heeded the NRC's call for more integration and collaboration. This has resulted, for example, in a new "Collaborative Science and Adaptive Management Program" (CSAMP) intended to improve the robustness and effectiveness of actions required to protect threatened and endangered fishes from adverse effects of operating the California State Water Project and the federal Central Valley Project.

While science alone cannot solve the Delta's problems, science that is responsive to and integrated with management and policy processes is a key component of any solution. At present, Delta science lacks the organization, support, and many of the approaches and tools needed to produce and communicate the highly credible, relevant, and legitimate science needed to guide durable and comprehensive policy solutions and support effective and robust management actions directed at balancing the coequal goals of achieving a more reliable water supply for California and protecting, restoring, and enhancing the Delta ecosystem.

The Delta Science Plan provides a vision, principles, and approaches for building on existing Delta science efforts and developing new ones so that Delta science can effectively and sustainably function as the strong and steady guide envisioned by the California legislature, Governor Brown, Secretary Salazar, the Delta Stewardship Council, the Delta science community, and many others. The Delta Science Plan is itself a guide; it provides principles and approaches that will guide Delta science efforts for years to come. The Delta Science Plan is targeted at all science efforts in the Delta, including established efforts such as the Delta Science Program and the Interagency Ecological Program, as well as new and emerging efforts such as CSAMP, the science efforts envisioned for the Bay Delta Conservation Plan (BDCP), and the many smaller science efforts associated with meeting the adaptive management requirements of the Delta Plan.

Implementation of the Delta Science Plan will help these science efforts grow and come together so they can effectively take on the many "high-stakes science" tasks and the "grand challenges"[3] of the Delta. The goals of the Delta Science Plan are to: 1) strengthen and unify the Delta science community; 2) assure the credibility, relevance, and legitimacy of Delta science; and 3) provide tools, organizational structures, and mechanisms for scientists, policymakers, managers, stakeholders, and the public that will help them more effectively collaborate on turning Delta science into effective action. Specifically,

[3] "Grand challenges" are large complex problems of importance to humankind, requiring numerous researchers, many years and appropriate resources to solve important national or global problems. A more complete definition is given in *Grand Challenges in the Environmental Sciences* (National Research Council 2001).

the Delta Science Plan addresses how to determine what science needs to be done in an open and transparent way, how it can be done most effectively and efficiently, and how it can best be made available to those who need to use it.

A Vision for Delta Science

This Plan lays the foundation for achieving a shared vision for Delta science; *'One Delta, One Science'* – an open Delta science community that works collaboratively to build a shared body of scientific knowledge with the capacity to adapt and inform future water and environmental decisions. The shared body of knowledge includes both natural and social sciences and will be broadly accepted as credible, relevant, and legitimate. It will provide a solid scientific basis for making difficult management decisions about the Delta. Transitioning from an outdated paradigm of scientists and resource managers operating in agency and program silos, an open science community that is well-connected with the policy and management community, as well as with other users of science, will have the capacity to adapt and inform future water and environmental decisions across multiple organizations and programs. It does not mean that the mandates of agencies are compromised, regulatory responsibilities are diminished, or bottom-up mechanisms for shaping the science community are lost. In fact, it is an essential intention of the Delta Science Plan to augment and build on existing efforts and improve the existing science infrastructure where synergies within the science community can be achieved. The concept is to develop a culture that accelerates the discovery of new information through shared priorities, data, and models. Alternative hypotheses, genuine differences in scientific opinion, new technologies, and a range of modeling approaches are embraced and explored in a structured and transparent manner to minimize the risk of having redundant, conclusion-driven, and non-transparent science stymie decision-makers.

What is the Delta Science Plan?

The Delta Science Plan is the first element of a three-part planning, implementation, and reporting strategy. The overall Delta Science Strategy includes:

1. ***The Delta Science Plan*** – A shared vision for Delta science and a living guide for organizing, conducting, and integrating science in the Delta. It establishes the major elements, organizational structures, and key actions for improving the efficiency, utility, and application of Delta science across many agencies and institutions and for assuring its credibility, relevance, and legitimacy.

2. ***The Science Action Agenda*** – This prioritizes and aligns near-term science actions to inform management actions and achieve the objectives of the Delta Science Plan. The Science Action Agenda identifies priorities for research, monitoring, data management, modeling, synthesis, communication, and building science capacity. Under the leadership of the Delta Science Program, the Science Action Agenda will be developed collaboratively with federal and State agencies, local government, science programs, academic institutions, stakeholders, and a Science Steering Committee.

3. ***The State of Bay-Delta Science (SBDS)*** – A synthesis of the current scientific knowledge for the Delta. Specifically, *SBDS* communicates the state of knowledge to address the grand challenges, including progress made on key research questions and remaining knowledge gaps, which are used to guide updates to the Action Agenda. It is updated by relevant science experts with guidance from the Science Steering Committee.

What Does the Delta Science Plan Achieve?

The Delta Science Plan proposes 30 actions intended to strengthen, organize, and communicate science to provide relevant, credible, and legitimate decision-support for policy and management actions. Ultimately, implementation of this Plan will result in a vibrant community of scientists working in the Delta in an integrated manner and producing the kind of highly credible, relevant, and legitimate science needed to address the high-stakes, grand management challenges of the present and future Delta. In this way, scientists will contribute to reducing risks to and increasing resilience of the State's water supply, the Delta ecosystem, and the Delta as a unique and evolving place.

Specifically, the Delta Science Plan will achieve the following objectives:

Enable and promote science synthesis – The Plan will establish a Science Steering Committee tasked with guiding science synthesis efforts to continually update the state of knowledge of the Delta system, address decision-makers' grand challenges, and identify and support shared [or "collaborative"] approaches for synthesis.

Manage scientific conflict – The Delta Science Plan seeks to manage scientific conflict and its relationship to management and policy decisions. Transparent processes using a variety of collaborative and independent approaches provide the highest caliber, relevant, and legitimate science to support Delta water and environmental management decisions.

Prioritize, coordinate and integrate Delta science in a transparent manner – Current fragmentation of science institutions and their different approaches to conducting and using science hinders efficient development and use of a common and trusted body of science for Delta decision-making. A shared approach for prioritizing, organizing, and integrating ongoing scientific research, monitoring, data management, analysis, synthesis, and communication is proposed through the Science Action Agenda and a web-based tracking system for Delta Science activities.

Build effective policy-science interactions – This Plan provides a new path forward for building effective interactions between resource decision-makers and scientists through establishing a Policy-Science Forum.

Strategic and topical support for effective adaptive management – Planning and implementation of adaptive management consistent with the Delta Plan's adaptive management framework is supported through a Restoration Framework and Water Management Framework. Knowledge will be transferred across different activities through an annual Adaptive Management Forum and Delta Science Program Adaptive Management Liaisons.

Identify, maintain and advance understanding about the Delta – Our understanding of the Delta system is advancing rapidly and is distributed across many institutions, which makes it difficult to integrate and communicate in a timely manner. This Plan will facilitate the maintenance and growth of shared Delta-wide knowledge through the activities of the Policy-Science Forum, Science Steering Committee and the Delta Science Program working with the Delta science community.

1. INTRODUCTION

"Through our joint federal-state partnership, and with science as our guide, we are taking a comprehensive approach to tackling California's water problems…"[4]

Today's Delta scientists have the responsibility to conduct science and communicate scientific results in a manner that informs decision-makers' actions to achieve the coequal goals of a more reliable water supply for California and protecting, restoring, and enhancing the Delta ecosystem, and to do so in a manner that protects and enhances the unique cultural, recreational, natural resource, and agricultural values of the Delta as an evolving place (Water Code §85054). There are few other locations in the world where the consequences of water management decisions bear such significant consequences to both economic development and sustaining a fragile ecosystem and unique place than the Delta.

As if these challenges were not enough, there is also considerable uncertainty and disagreement about the goals and likely outcome of many proposed and existing water management actions. This makes them economically, legally, politically, and environmentally risky. Balancing the risks of different actions (or inaction) is at least as challenging as identifying actions in the first place. Reducing risk by reducing uncertainty and disagreement is thus of paramount importance.

Uncertainty results from incomplete scientific information combined with complex and constantly changing management contexts, while disagreement results from conflicting human interests, perspectives, and different interpretations and uses of scientific data and information. Science can help reduce uncertainty and disagreement, but as the NRC pointed out, "science alone cannot solve the Delta's problems" (NRC 2012, p. 190) and more integrative strategies and approaches are needed. These include science-based adaptive management and collaborative planning strategies that involve and integrate scientists, managers, decision-makers, stakeholders, and the public. Adaptive management can help reduce uncertainty while collaborative planning can help reduce disagreement. Combined into "collaborative adaptive management" (Scarlett 2013), these strategies underlie, for example, a new "Collaborative Science and Adaptive Management Program" (CSAMP) that includes State and federal water and fish agencies, stakeholders, and scientists. In the long-run, these strategies and approaches promise to achieve more effective and robust actions and better management outcomes. In the short-term, however, such strategies often appear very costly, slow, and risky. To be successful, they require broad, honest, and sustained commitment and investment by all participants as well as strong and principled leadership. This is difficult when the stakes are as high, interests as strongly at odds, and action as urgently needed as in the Delta.

With the stakes so high and the challenges so great, there is no question that most science in and about the Delta is *high stakes* science. At the same time, science in the complex and constantly changing Delta system is a journey, not a destination, with the body of knowledge continuously expanding and evolving as more is understood, some uncertainties are reduced, and new uncertainties emerge. Examples of

[4] From July 25, 2012 Governor Brown and Obama Administration joint announcement on the proposed path forward for the Bay Delta Conservation Plan and California's water future.

continuing improvement of technologies, models, and understanding abound in several scientific disciplines. For example, in the field of weather forecasting, a concerted and collaborative effort by the extreme weather prediction community has extended our ability to predict the track of storms from two days to close to the theoretical maximum of 14 days with increasing reliability (Droegemeier 2013), resulting in massive reductions in loss of life and property damage. However, this has also opened up many new uncertainties about how to best prepare for and respond to hurricanes now that there is more warning time.

The Delta Science Plan provides a vision, principles, and approaches that will guide Delta science for years to come. Implementation of the Delta Science Plan will generate and distribute credible, relevant, and legitimate scientific information capable of predicting alternative futures for California's water supply reliability and environment. This science will serve as a strong guide for managing the challenging water and environmental decisions that influence the lives of Californians today and for future generations. The goals of the Delta Science Plan are to 1) strengthen and unify the Delta science community, 2) assure the credibility, relevance, and legitimacy of Delta science, and 3) provide tools, organizational structures, and mechanisms for scientists, policymakers, managers, stakeholders, and the public that will help them more effectively collaborate on turning Delta science into effective action. The Delta Science Plan enhances existing collaboration among scientists and with others and provides processes and the fundamental infrastructure essential to conduct and communicate scientific activities. Achieving the goals of the Delta Science Plan will lead to a vibrant science community that is producing the kind of highly credible, relevant, and legitimate science needed to address the high-stakes, grand management challenges of the present and future Delta.

The Delta Science Plan covers the geographic extent of the Sacramento-San Joaquin Delta (as defined in Section 12220 of the California Water Code) and Suisun Marsh (as defined in Section 29101 of the Public Resources Code). It is recognized that the Delta is linked to San Francisco Bay and the Pacific Ocean on the downstream boundary and to the Central Valley and Delta Watershed at the upstream boundary. Collaboration with scientific activities in these areas is essential to fully understand the consequences of management actions.

What is the Problem?

The Delta is faced with a plethora of risks and challenges and there is now doubt that decisive action is urgently needed, but existing and proposed policy solutions and management actions are perpetually plagued by high levels of uncertainty and disagreement about their suitability and effectiveness. Science alone cannot solve the Delta's problems, but science that is responsive to and integrated with management and policy processes is a key component of any solution. **At present, Delta science lacks the organization, support, and many of the approaches and tools needed to produce and communicate the highly credible, relevant, and legitimate science needed to guide durable and comprehensive policy solutions and support effective and robust management actions for achieving the coequal goals.**

The Delta is lacking a common process for prioritizing and funding science activities, building its science infrastructure, and supporting and developing the science community. Of the many science efforts in the Delta, few address more than a single objective. The Delta Plan summarizes this problem:

> "*Currently, science efforts related to the Delta are performed by multiple entities with multiple agendas and without an overarching plan for coordinating data management and information sharing among entities. Increasingly, resource management decisions are made in the courtroom as conflicting science thwarts decision making and delays action. Multiple frameworks for science in the Delta have been proposed, but a comprehensive science plan that organizes and integrates ongoing scientific research, monitoring, analysis, and data management among entities has yet to be fully formulated.*"*(p. 54)*

Science will continue to occur in program silos with limited integration in the absence of a common vision and strategy for Delta science. Managers and policymakers will continue to bemoan the lack of credible and legitimate science that is relevant to their needs without better connections among policy makers, scientists, and managers. Conflicts over science will continue without collaborative approaches for developing a common understanding of problems, sharing knowledge, and developing innovative solutions.

Efforts to Build On:

- Collaborative science planning efforts by the IEP, BDCP, SWRCB, Biological Opinions Remand Process, California Water Plan Update Process and the South Delta Salmonid Research Collaborative
- Multi-agency sponsorship of Delta Science Fellows solicitations
- Recent SWRCB workshops
- Research needs identified by BDCP
- Delta Science Program and Ecosystem Restoration Proposal Solicitation Package processes for identifying research priorities
- IEP Management Analysis and Synthesis Team (MAST) pilot effort

Implementation of the Delta Reform Act (Act) and the Delta Stewardship Council's Delta Plan depend on science support (Water Code §85020(h)) to achieve the coequal goals. Significant scientific investments have been and continue to be made to better understand the Delta[5] and inform water and environmental management decisions. However, despite a rich history of scientific study and more than half a century of monitoring the aquatic system, insufficient integration, coordination, cooperation, and communication weaken efficient development and effective use of best available science to inform decision-making as required by the Act.

How does the Delta Science Plan Address the Problem?

This Delta Science Plan builds on existing efforts to provide a new path forward to achieve the vision of *One Delta, One Science* (Box 1-1). It articulates a broad and adaptable framework to accelerate the discovery of new

BOX 1-1 VISION

The Delta Science Plan aims to achieve the vision of '*One Delta, One Science'* – an open Delta science community that works collaboratively to build a shared body of scientific knowledge with the capacity to adapt and inform future water and environmental decisions.

[5] The Sacramento-San Joaquin Delta and Suisun Marsh are referred to throughout this document collectively as "the Delta."

understanding by organizing and integrating science through shared priorities, data, and models. It embraces alternative hypotheses, genuine differences in scientific opinion, emerging technologies, and fosters model enhancement and accessibility. The Delta Science Plan creates the institutional capacity to support, enhance and network science activities such as adaptive management decision-making required by the 2009 Delta Reform Act and the 2013 Delta Plan (Box 1-2). It is a renewed commitment and intentional effort to improve the development, delivery and communication of science so that decision makers have the best scientific information and tools available when confronted with tough decisions related to the Delta.

Implementation of the Delta Science Plan will result in a vibrant community of scientists working in the Delta in an integrated and collaborative manner. This community will produce the kind of highly credible, relevant, and legitimate science needed to inform decisions and actions to address the high-stakes, grand management challenges of the present and future Delta. The Delta science envisioned in the Delta Science Plan will effectively inform decisions, but it expressly will not pass value judgment on the trade-offs among different decisions, which resides with the responsible agency. The Delta Science Plan also fully recognizes the needs for agencies to meet their missions and regulatory responsibilities.

Science Action Agenda and *The State of Bay-Delta Science*

The Delta Science Plan is developed as one of three elements of an overall Delta Science Strategy for achieving the vision of *One Delta, One Science*. The other two elements of the Delta Science Strategy include the *Science Action Agenda* (Action 2.2) and *The State of Bay-Delta Science* (Action 2.6).

The Science Action Agenda (Action Agenda) establishes the prioritized science actions to achieve the objectives of the Delta Science Plan. The Action Agenda identifies priorities for science activities (i.e., research, monitoring, data management, modeling, synthesis and communication) to address decision-makers' "grand challenges"[6] over a four-year period. The Action Agenda will be a shared agenda for science programs in the Delta that are housed in multiple federal, State and local agencies, universities, and non-governmental organizations. It will serve as the common agenda from which agencies and programs can develop their science work plans (e.g., the Interagency Ecological Program Work Plan).

The State of Bay-Delta Science (SBDS) is a summary synthesis of the current scientific knowledge for the Delta. Specifically, *SBDS* communicates the state of knowledge to address the grand challenges, including progress made on key research questions and remaining knowledge gaps, which are used to guide updates to the Action Agenda.

[6] "Grand challenges" are large complex problems of importance to humankind, requiring numerous researchers, many years and appropriate resources to solve important national or global problems. A more complete definition is given in *Grand Challenges in the Environmental Sciences* (National Research Council 2001).

BOX 1-2 DELTA SCIENCE PLAN SUPPORT FOR DELTA PLAN

"[The Delta Science Plan] is essential to support the adaptive management of ecosystem restoration and water management decisions in the Delta." - Delta Plan

The following highlights the relationship of the Delta Science Plan to implementation of the 2009 Delta Reform Act and the Delta Stewardship Council's Delta Plan. The Delta Reform Act requires the Delta Plan to be based on and implemented using best available science. Furthermore, the legislation requires the use of science-based, transparent and formal adaptive management strategies for ongoing ecosystem restoration and water-management decisions. The Delta Plan also identifies the need for a comprehensive science plan for the Delta and recommends that the Delta Science Program, working with others, develop a Delta Science Plan that creates an overarching road map for organizing and integrating ongoing scientific research, monitoring, analysis and data management among entities by December 31, 2013. To ensure that best science is used to develop the Delta Science Plan, the Delta Plan recommends that the Delta Independent Science Board review the draft Delta Science Plan.

The Delta Science Plan supports implementation of the Delta Reform Act and the Delta Plan through:

1. Carrying out the Delta Science Program's responsibilities to, "develop, coordinate and provide the best possible and transparent scientific information to inform water and environmental decision making in the Delta." (Water Code § 85280 (b)(4))
2. Promoting and providing best available science and adaptive management support for implementing the Delta Plan (Water Code § 85308 (a) and (f); Delta Plan GP 1)
3. Monitoring and evaluating progress toward achieving the coequal goals (Delta Plan Ch. 2; Water Code § 85308 (c))
4. Addressing science and information needs in the Delta Plan (Delta Plan Ch. 2, 3, 4, and 6; Water Code §85308 (e))
5. Supporting communication of science to inform Delta Plan implementation (Delta Plan Ch. 2)
6. Providing a strategy for leveraging reliable funding to sustain needed science advancements and infrastructure

What are the Objectives of the Delta Science Plan?

Enable and Promote Science Synthesis - The lack of a collaborative mechanism and high-level guidance and support for rigorous and ongoing synthesis that is well-aligned with the information needs of decision-makers hinders the timely translation of data and information into usable knowledge and, ultimately, effective action. This plan will establish a Science Steering Committee (facilitated by the Delta Science Program) tasked with guiding science synthesis efforts to address decision-makers' grand challenges (Action 2.4). It also takes action to enable and identify resources for focused science synthesis efforts through directed action or self-forming groups in response to requests for proposals (Action 2.5).

Manage Scientific Conflict - Conflicts and disagreement are a normal and healthy part of the scientific enterprise. They are often about which conceptual or quantitative model best explains observed responses to natural events or human actions. They give rise to testable hypotheses and experimental designs and thus fuel scientific progress. However, they also pose challenges for turning science into action and for prioritizing additional science. Agencies charged with regulating and managing natural resources are often faced with a confusing flood of information, scientific and otherwise. For example, which models should managers "believe" and use? What else do they really need to know? These difficulties are compounded by the fact that the time taken for the scientific process to develop new understanding is incompatible with the time frame within which many Delta management decisions must be made. This often gives rise to conflicts and strongly diverging ideas about what to do. Conflicts about what to do are especially common and severe when the stakes are high and values, interests, and policy goals diverge, as is the case in the Delta. Somewhat paradoxically, the availability of large amounts of scientific data can actually make these conflicts worse because it allows parties with different interests and ideas to selectively use the data to present their views in the form of scientific conclusions - as the British economist Ronald Coase observed in a talk at the University of Virginia in the early 1960s: "If you torture the data enough, nature will always confess.” This shifts the focus from a conflict over values, interests, and policy goals to a conflict that is seemingly about science and is often used as grounds for legal proceedings or delay.

The Delta Science Plan recognizes these challenges and offers a range of options to clarify the nature of these conflicts, manage them, and deliver credible, relevant, and legitimate scientific information in a timely, independent and transparent manner. In particular, the Delta Science Plan seeks to clarify and manage scientific conflict and its relationship to management and policy conflicts through transparent processes that make use of a variety of collaborative and independent approaches aimed at providing the highest caliber, relevant, and legitimate science to support Delta water and environmental management decisions.

The processes described in this Plan will help to clarify and manage scientific conflict at every step, from identification of grand challenges in a Policy-Science Forum (Action 2.1) to effective communication of the results of high-priority research. The Action Agenda will direct resources to the highest priority issues, and the web-based tracking system (Action 2.3) will make information about research and other science activities available to all. Chapter 3 describes how collaborative science is integrated with and used in adaptive management to help resource managers make better decisions in the face of uncertainty and disagreement. Peer review (Action 4.6.1) helps to ensure the credibility and quality of the science that underlies Delta decisions. Synthesis tools (Action 4.5.1) build higher-level understanding of key issues and can help to provide an independent and authoritative assessment of the available scientific information. Expert panel workshops are a particularly useful tool for timely synthesis of scientific information and managing conflict.

Coordinate and Integrate Delta Science in a Transparent Manner – The Little Hoover Commission (2010), the NRC (2012), and many others have concluded that “management of the water and environment of the Delta is fragmented” (NRC 2012, p.167). This observation also extends to Delta science because many of the existing Delta science efforts are closely associated with or housed in agency units that deal with very specific problems and do not coordinate with other agencies or even within other units within the same agency. In spite of existing efforts to coordinate and integrate Delta science, fragmentation of Delta science persists and hinders efficient development and use of a common and trusted body of science for Delta decision-making. These fragmented science institutions do not have the individual capacity or mandate to address grand challenges that require a long-term inter-disciplinary concerted effort. This Plan addresses grand challenges through a shared approach for organizing and integrating ongoing scientific research, monitoring, data management, analysis, synthesis and communication. This is accomplished through both the Action Agenda (Action 2.2) and building and sustaining a web-based tracking system that inventories and tracks Delta Science activities (Action 2.3). In addition, the Delta Science Plan also seeks to strengthen and build on existing efforts to coordinate and integrate Delta science.

***Build Effective Policy-Science Interactions* -** Opportunities for effective interactions between decision-makers and the broad science community are limited. Furthermore, the roles of science (to inform decision-making) and the roles of policy and managers (to prioritize and make decisions) are not always clearly understood. Challenges to communicate and develop a shared understanding of needs, opportunities, and roles at these interfaces have led to considerable frustration. This Plan provides a new approach for building effective interactions at these interfaces through establishing a Policy-Science Forum, which includes directors of federal and State agencies, Delta science leaders, and select members of the Science Steering Committee (Action 2.4). This forum will facilitate shared understanding of policy priorities and scientific information and direct communication of new understanding into actionable alternatives for management and policy changes.

***Strategic and Topical Support for Effective Adaptive Management* -** Past attempts to adaptively manage Delta water operations and ecosystem restoration have rarely covered the full adaptive management cycle (Plan, Do, Evaluate and Respond). There has also been much disagreement about suitable adaptive management actions and the science needed to evaluate their effectiveness. There is a risk of not being able to attain or quantify system-level progress toward achieving the coequal goals if multiple adaptive management efforts remain perpetually contested, incomplete, nonintegrated, respond too slowly, or fail to consider system-wide and local effects. Under the Delta Science Plan, adaptive management implementation will be integrated through a Restoration Framework, a Water Management Framework and Delta Science Program Adaptive Management Liaisons (Chapter 3).

***Identify, maintain and advance understanding about the Delta* -** The state of knowledge of the Delta system is advancing rapidly and distributed across many institutions, which makes it difficult to assimilate and synthesize in a timely manner. This plan will facilitate the maintenance and growth of Delta-wide knowledge through the activities of the Policy-Science Forum, Science Steering Committee and the Delta Science Program. The Science Steering Committee and Policy-Science Forum will play key roles in providing guidance for prioritizing research (Section 4.1), integrating monitoring and associated research (Section 4.2) and conducting targeted and ongoing synthesis activities (Section 4.5). The Delta Science Program with others will facilitate Delta-wide approaches for data management and accessibility (Section 4.3), shared models (Section 4.4) and independent peer review (Section 4.6). To more effectively inform policy and management decisions and the public, this plan initiates a science communication strategy for the Delta (Section 4.7).

What will the Delta Science Plan Achieve?

The Delta Science Plan aims to achieve *One Delta, One Science* – an open Delta science community that works collaboratively to build a shared body of scientific knowledge with the capacity to adapt and inform future water and environmental decisions. To achieve this vision, the Delta Science Plan will serve as the coordinated and targeted science plan for ongoing and future Delta science. As a living guide, the Delta Science Plan retains the flexibility for innovation and responsiveness to emerging issues such as natural disasters.

The Delta Science Plan lays out 30 actions intended to strengthen the organization and communication of science for credible, relevant, and legitimate decision support for policy and management actions.

Implementation of this Plan will result in a suite of options available for developing and packaging responses to decision-makers' science needs (e.g., summaries of the state of knowledge and science-expert advice conveyed by the Delta Lead Scientist or Science Steering Committee). It establishes resources and time for scientists working for agencies to participate in synthesis activities that address priorities. Ultimately, implementation of this Plan will result in a community of scientists working in the Delta in an integrated manner, contributing to the increased reliability of the State's water supply and an improved Delta ecosystem that is more resilient and favors native species.

To ensure that these outcomes and the objectives of the Delta Science Plan are achieved, performance measures and metrics will be developed (Action 2.8). Outcomes of the Delta Science Plan and progress toward achieving its objectives will be evaluated based on these performance measures. This will allow the Delta Science Plan to be refined and updated to foster innovation and maximize the generation of new knowledge to inform the grand challenges confronting Delta policymakers and managers. The first assessment will be conducted on the first year of Delta Science Plan implementation. Following this initial assessment and associated adjustments, the Delta Science Plan will be updated at least once every five years or more often as needed, in parallel with major revisions to the Delta Plan as appropriate.

Organization of the Delta Science Plan

The Delta Science Plan is organized around central elements for achieving the vision of *One Delta, One Science*. The following chapters describe in detail the problems, objectives, actions, and expected outcomes for:

- Chapter 2, Organizing science to inform policy and management
- Chapter 3, Adaptive management for a complex system
- Chapter 4, Building the infrastructure for science
    - Section 4.1, Funding research
    - Section 4.2, Monitoring and associated research
    - Section 4.3, Data management and accessibility
    - Section 4.4, Shared modeling
    - Section 4.5, Synthesis for system-wide perspectives
    - Section 4.6, Independent scientific peer review and advice
    - Section 4.7, Communication
- Chapter 5, Resources to implement the Delta Science Plan

Background information and a box highlighting "Efforts to Build On" are also found within each chapter and major section. These existing efforts are intended as examples of the depth of quality scientific activities that will contribute and are not intended to be comprehensive. Actions are described in short within the Delta Science Plan. The Science Action Agenda will flesh out the actions sketched in the Science Plan. Several actions refer to appendices for details, including processes and roles and responsibilities of action participants. For each action or suite of actions the primary responsibility (i.e., facilitating or leading) is assigned and action participants (i.e., joint development or implementation responsibilities) are identified.

A summary table of actions is provided following the chapters. The table categorizes each action as new, ongoing (sufficiently underway), or enhanced (underway and in need of additional resources to achieve objectives). The actions are also prioritized based on their ability to have the greatest short- and long-term impacts on science, balanced against the feasibility of the actions. The priority categories are defined as: a) Immediate – within the first year of Plan implementation; b) Near term – within years 2-5; and c) Longer term – beyond the first five years of Plan implementation. A list of the immediate high-priority actions is provided below (Table 1-1).

Table 1-1. Immediate (addressed within the first year of Plan implementation) high-priority actions.

Action Number	Short-title	Action Type
2.1	Establish a Policy-Science Forum	New
2.2	Develop, implement, and update a Science Action Agenda	New
2.4	Establish a Science Steering Committee	New
2.7	Deliver annual State-of-Delta science address	New
3.1	Provide Adaptive Management Liaisons	Enhanced
4.3.1	Host a data summit	New
4.4.1	Develop a collaborative community modeling framework	Enhanced
4.4.3	Support high-priority model development	Enhanced
4.5.2	Establish mechanisms and protocols for ongoing synthesis	Enhanced
4.6.1	Seek broad support and use of a standard process for conducting scientific peer review	Enhanced
5.1	Develop a joint funding strategy for the Delta Science Plan	Enhanced

2. ORGANIZING SCIENCE TO INFORM POLICY AND MANAGEMENT

"A collaborative effort is needed, where scientists and governance professionals work together as a single team, rather than two separate entities."[7]

Transforming how policy, science, and management communities engage is essential for identifying and addressing complex questions and issues surrounding natural resources management in the Delta. Transformation requires adjusting the way we work as policymakers, scientists, and resource managers, learning each other's "language," and embracing a team approach. This Plan establishes and strengthens forums for decision-makers and scientists to work together to articulate problems, set goals and priorities, increase understanding, and share in progress toward achieving the coequal goals. This is accomplished through early engagement, continuous dialogue, and opportunities to develop innovative approaches for using best available science.

Efforts to Build On:

- Town Hall Meeting with policymakers and the science community at the 2012 Bay-Delta Science Conference
- 2012 DSP-coordinated invited Science Expert Panels to synthesize the state of knowledge for State Water Resources Control Board members for the Bay-Delta Plan Phase 2 Update.
- IEP Science Advisory Group
- National trends of science networks: (i.e., Network for Earthquake Engineering Simulation (NEES)

Action in this chapter are organized into four sections, 1) Improve policy-science interactions, 2) Integrate and track science activities, 3) Guide and support synthesis, and 4) Update and communicate the state of science and Delta Science Plan performance. Collectively, these actions provide new mechanisms, structures, and tools to support regular and effective interactions among policymakers, scientists, and managers, resulting in improved shared understanding and stewardship of the Delta (Figure 2-1).

[7] National Research Council on Sustainability of Water and Environmental Management in the California Bay-Delta Report (2012), Page 175

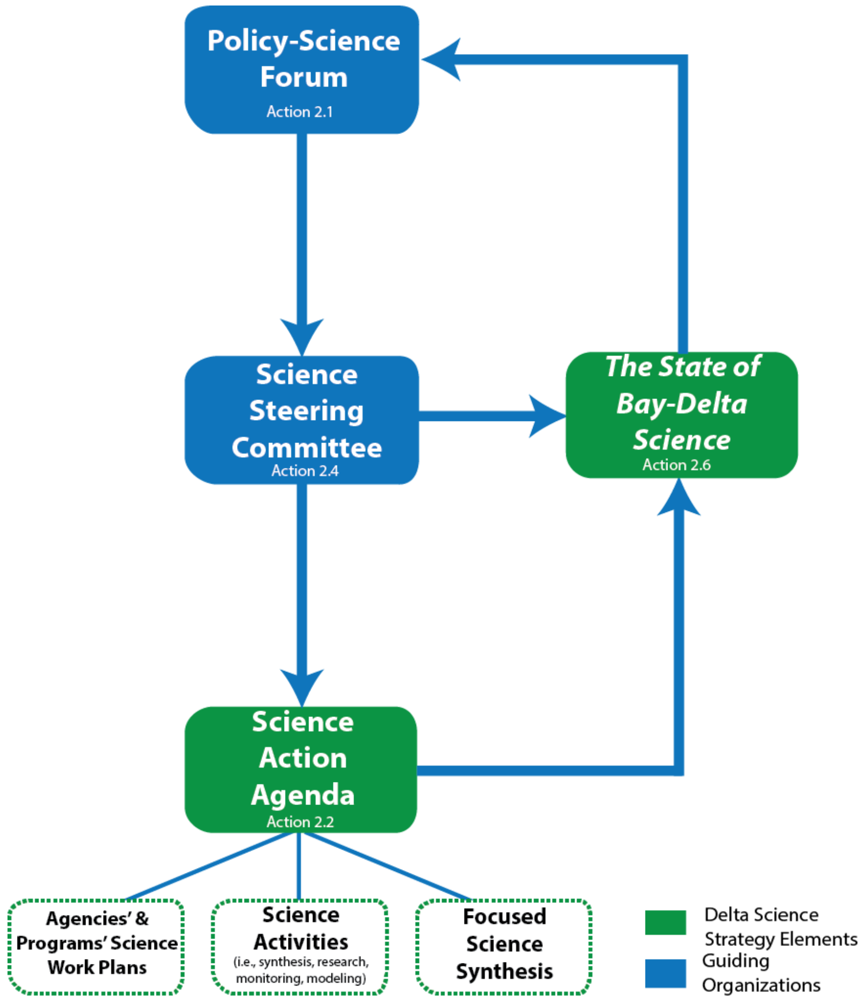

Figure 2-1. A summary of how science is organized to inform policy and management. Arrows represent the general connection and flow of guidance and information among organizational elements (the Policy-Science Forum and the Science Steering Committee) and Delta Science Strategy elements (the Science Action Agenda and *The State of Bay-Delta Science)*. Implementation of the Science Action Agenda is carried out through agencies' and programs' science work plans, a number of science activities, and focused science synthesis. Note that focused science syntheses and other products resulting from implementing the Science Action Agenda will also be provided to the Policy-Science Forum as appropriate.

Improve policy-science interactions

Problem Statement

Effective interactions between decision-makers and scientists that transcend individual organizations are not clearly established for communicating grand challenges, exploring issues, and building understanding about the science needed and/or available to support management decisions. A regular forum does not exist for building trust among the scientists that inform decision-making and the policymakers that make decisions. Without this forum, joint identification and communication of key scientific uncertainties is limited, which reduces the effectiveness and return on investment for restoration and water-management actions.

Objectives

- Establish a shared approach for identifying and communicating decision-makers' grand challenges and the associated priorities for research, monitoring, and evaluation to address these challenges (Box 2-1)
- Institute forums for identifying and communicating the key scientific uncertainties and understandings to decision-makers
- Define mechanisms for early engagement of decision-makers in setting research and monitoring priorities, continuous dialogue, and effective use of best available science to inform decision-making

Box 2-1 Examples of grand challenges and associated science actions

- Grand challenge: Fully understand the dynamic state of the estuary, which includes knowledge about how the primary stressors (flow alterations, morphology, invasive species, excess nutrients, etc.) affect ecosystem outcomes and water supply reliability.

  Science action: Coordinate monitoring and analysis programs (e.g., USGS, DWR, CDFW, and Delta RMP) fund competitive special studies (i.e., Fall Low Salinity Habitat (FLaSH) studies) and support focused analysis and synthesis of results and management implications.

- Grand challenge: Anticipate changes to the geometry and/or state of the system from high-magnitude and random events (e.g., floods, seismic events, toxic spills, or invasion by quagga mussels).

  Science action: Build interoperable interdisciplinary models that predict system responses to management actions in response to high-magnitude and random events.

Actions

2.1 **Establish a Policy-Science Forum**

Establish a Policy-Science Forum where directors of federal and State agencies and science leaders discuss key issues (e.g., drought, introduction of native species) to: a) communicate grand challenges; b) explore issues directly with leaders of the scientific community so that scientists fully understand the science needed to support decisions and how that science can be best used; c) communicate best available science to support decision-making; and d) recommend workgroups as needed to collaboratively analyze policy alternatives and advise adaptive management of policies and programs [Appendix B].

Primary Responsibility: Delta Science Program

Action Participants: Federal and State agency directors, Lead/Chief Scientists with responsibilities in the Delta, relevant science leaders identified by the Lead Scientist (i.e., the IEP Lead Scientist, BDCP Science Manager, leading academic researchers, and research program directors), Science Steering Committee, stakeholders

Expected Outcomes

- Improved interactions at the policy-science-management interfaces
- Shared understanding of best available science and critical uncertainties among scientists and decision-makers

Integrate and track science activities

Problem Statement

Currently, science efforts related to the Delta are performed by multiple entities with multiple agendas (Delta Stewardship Council 2013). Despite current science coordination through the Interagency Ecological Program and other efforts, science work plans and implementation programs remain fragmented without a common agenda.

Objectives

- Establish a shared science agenda to direct and integrate science actions performed by multiple programs and agencies in the Delta
- Inventory and track science activities in the Delta

Actions

2.2 **Develop, implement, and update a Science Action Agenda**

Develop, implement, and update a Science Action Agenda through an inclusive process that organizes, integrates, and prioritizes science activities across agencies and programs to address decision-makers' grand challenges in an efficient manner [Appendix C].

Primary Responsibility: Delta Science Program, Science Steering Committee, and agency directors

Action Participants: IEP, BDCP, Ecosystem Restoration Program (ERP), CWQMC, State and Federal Contractors Water Agency (SFCWA) and other science programs of federal, State, and local agencies

2.3 **Sustain a web-based tracking system of science activities**

Refine and expand existing efforts to develop and sustain a web-based tracking system to inventory and track research projects, monitoring, modeling, data management, synthesis, peer review, and other science activities to improve the transparency of science activities in the Delta.

Primary Responsibility: Delta Science Program

Action Participants: IEP, BDCP, ERP, CWQMC, SFCWA, Sacramento Regional County Sanitation District (SRCSD) and other science programs of federal, State, and local agencies

Expected Outcomes

- Ongoing and collaborative prioritization of science actions
- Integrated science efforts and work plans among agencies and programs
- Improved coordination and transparency of science activities

Guide and support synthesis

Problem Statement

Current science institutions do not have the capacity to conduct the synthesis activities needed to inform actions for achieving the coequal goals. Collaborative mechanisms to support the synthesis and translation of information into usable knowledge are needed, in addition to a routine publication or update of the state of scientific knowledge about the Delta system.

Objective

- Build the collaborative capacity to expand and sustain ongoing science synthesis and communicate shared scientific understanding

Actions

2.4 **Establish a Science Steering Committee**

Establish a Science Steering Committee that guides and advises science efforts to address current and anticipated grand challenges and inform decision-making through:

1) Translating the grand challenges articulated at the Policy-Science Forum into specific research priorities and actionable questions
2) Providing high-level guidance and prioritization of science actions to be addressed in the Action Agenda (e.g., research topics)
3) Recommending topics for focused science synthesis efforts (including requests for proposals)
4) Providing guidance to science experts writing SBDS
5) Conducting science synthesis in sub-groups
6) Representing the One Delta, One Science-Community at Policy-Science Forums [Appendix D]

<u>Primary Responsibility</u>: Delta Science Program

<u>Action Participants</u>: Delta Lead Scientist, Policy-Science Forum participants, individual scientists with relevant expertise (Delta scientists)

2.5 **Enable and identify resources for focused science synthesis**

Enable and identify resources for focused science synthesis teams that distill the state of knowledge on specific topics (e.g., what is the role of ammonia/ammonium within the Delta ecosystem?). Focused science synthesis teams will address directed actions and independently form a response to requests for proposals (RFPs) for interdisciplinary synthesis activities.

<u>Primary Responsibility</u>: Delta Science Program

<u>Action Participants</u>: Science Steering Committee, Delta Lead Scientist, scientists, science programs of federal, State, and local agencies

2.6 **Publish and update *The State of Bay-Delta Science***

Publish and update *The State of Bay-Delta Science* at least once every four years, aligned with the Biennial Bay-Delta Science Conference (offset from development of the Action Agenda) to regularly update and communicate the state of knowledge about the Delta system [Appendix E].

<u>Primary Responsibility</u>: Delta Science Program, Delta Lead Scientist

<u>Action Participants</u>: Relevant experts, the Science Steering Committee

Expected Outcomes

- Synthesizing scientific information is an ongoing activity
- Science synthesis efforts can be undertaken at short notice to address critical issues identified by decision-makers
- Synthesized science (e.g., state of knowledge reports or interdisciplinary models like CASCaDE) is provided to decision-makers to inform policy and management decisions through joint exploration of "what if" questions and evaluation of alternative futures
- Regularly update and communicate the state of scientific knowledge about the Delta system
- Ongoing assessments of the state of scientific knowledge that reflects the dynamic nature of the Delta-system, advances in technologies and the rapidly growing knowledge base

Communicate the state of science and Delta Science Plan performance

Problem Statement

Failure to communicate the state of scientific knowledge about the Delta system leads to outdated information used in important decisions. Also, performance measures and metrics are needed to evaluate and report Delta Science Plan performance and inform future refinements to the plan.

Objective

- Regularly communicate the state of scientific knowledge about the Delta system
- Develop performance measures for evaluating and reporting on Delta Science Plan performance

Actions

2.7 **Deliver annual state-of-Delta science address**

The Delta Lead Scientist, in consultation with Delta scientists, will deliver an annual review of Delta science. Depending on the point in the four-year cycle of science, the presentation will highlight the Science Action Agenda, *The State of Bay-Delta Science,* and key questions, findings, and innovations. This address will occur at a suitable venue and will be webcast and archived on the Delta Stewardship Council webpage.

<u>Primary Responsibility</u>: Delta Science Program, Delta Lead Scientist

<u>Action Participants</u>: Relevant experts, the Science Steering Committee

2.8 **Develop and report performance measures**

Measures and metrics will be developed to evaluate Delta Science Plan performance [Appendix A]. Parameters will be tracked that capture the development and impacts of the proposed science infrastructure, the role of science in guiding adaptive management, the use of best available science, and the effectiveness of the organization of science in guiding future refinements of the Delta Science Plan.

Performance monitoring will be conducted and will include surveys and selected interviews with representatives of all the contributors, users, and beneficiaries of the Delta Science Plan.

Primary Responsibility: Delta Science Program, Delta Lead Scientist

Action Participants: Relevant experts, the Science Steering Committee, and independent third parties

Expected Outcome

- Regularly communicate the state of scientific knowledge about the Delta system
- Transparent reporting of Delta Science Plan performance based on performance evaluations and other tools

3. ADAPTIVE MANAGEMENT FOR A COMPLEX SYSTEM

"'Adaptive Management' means a framework and flexible decision making process for ongoing knowledge acquisition, monitoring, and evaluation leading to continuous improvement in management planning and implementation of a project to achieve specified objectives."[8]

Many Delta planning and policy efforts have adopted adaptive management as the path forward for managing complex natural resources programs and projects (Box 3-1). Adaptive management is a strategy for proceeding with management decisions under uncertain conditions rather than delaying action until more information is available or adopting a rigid, prescriptive approach. An adaptive management approach is appropriate when management actions can be taken to influence the system to achieve a desired outcome and when uncertainty about the impact of management actions is high (Williams, et al. 2007)

Box 3-1 Example plans for the Delta proposing to use adaptive management

- Delta Plan
- Draft Bay Delta Conservation Plan
- Bay-Delta Water Quality Control Plan
- Water Quality Control Plans for the Bay Area and Central Valley Regional Boards
- Central Valley Project/State Water Project (CVP/SWP) Biological Opinions
  - Real-time Water Operations
  - Collaborative Science and Adaptive Management Program (CSAMP)
  - Fish Restoration Program Agreement (FRPA)
  - Yolo Bypass Salmonid Restoration and Fish Passage Implementation Plan
- Ecosystem Restoration Program Conservation Strategy
- Suisun Marsh Plan
- California Water Plan
- Integrated Regional Water Management Plans

Adaptive management has been successfully applied at the individual project level, but rarely at the programmatic and landscape scales. The Delta Independent Science Board was specifically designated in the Delta Reform Act to oversee the implementation of this challenge. To successfully implement adaptive management at the large scale of the Delta, new strategies are needed to better define and describe the roles and responsibilities of policy, science, and management. The roles and responsibilities of stakeholders and the general public also need to be clarified because they are often affected by adaptive management projects or directly participate in them. These new strategies need to allow for decisions that involve different time periods, different geographic areas of the Delta, and different water management and ecological issues. Adaptive management is a continuous and iterative process, in which new insights and solutions are used to improve understanding of the problem, which in turn leads to the next generation of actions based on lessons learned from previous actions.

Actions in this chapter are based on the three-phase, nine-step adaptive management process outlined in the Delta Plan (Figure 3-1). These actions build on the structures and processes identified in Chapter 2 and require science tools and resources, such as models, monitoring support, and other elements of the science infrastructure that are described in Chapter 4 in order to be successfully implemented.

[8] Water Code § 85052

This chapter includes actions that enable resources and tools (e.g., models that evaluate outcomes of alternative restoration designs for priority restoration areas (Action 3.3)) for those engaged in adaptive management. It also focuses on advancing the continuous application and acquisition of new knowledge in water management and ecosystem restoration decisions.

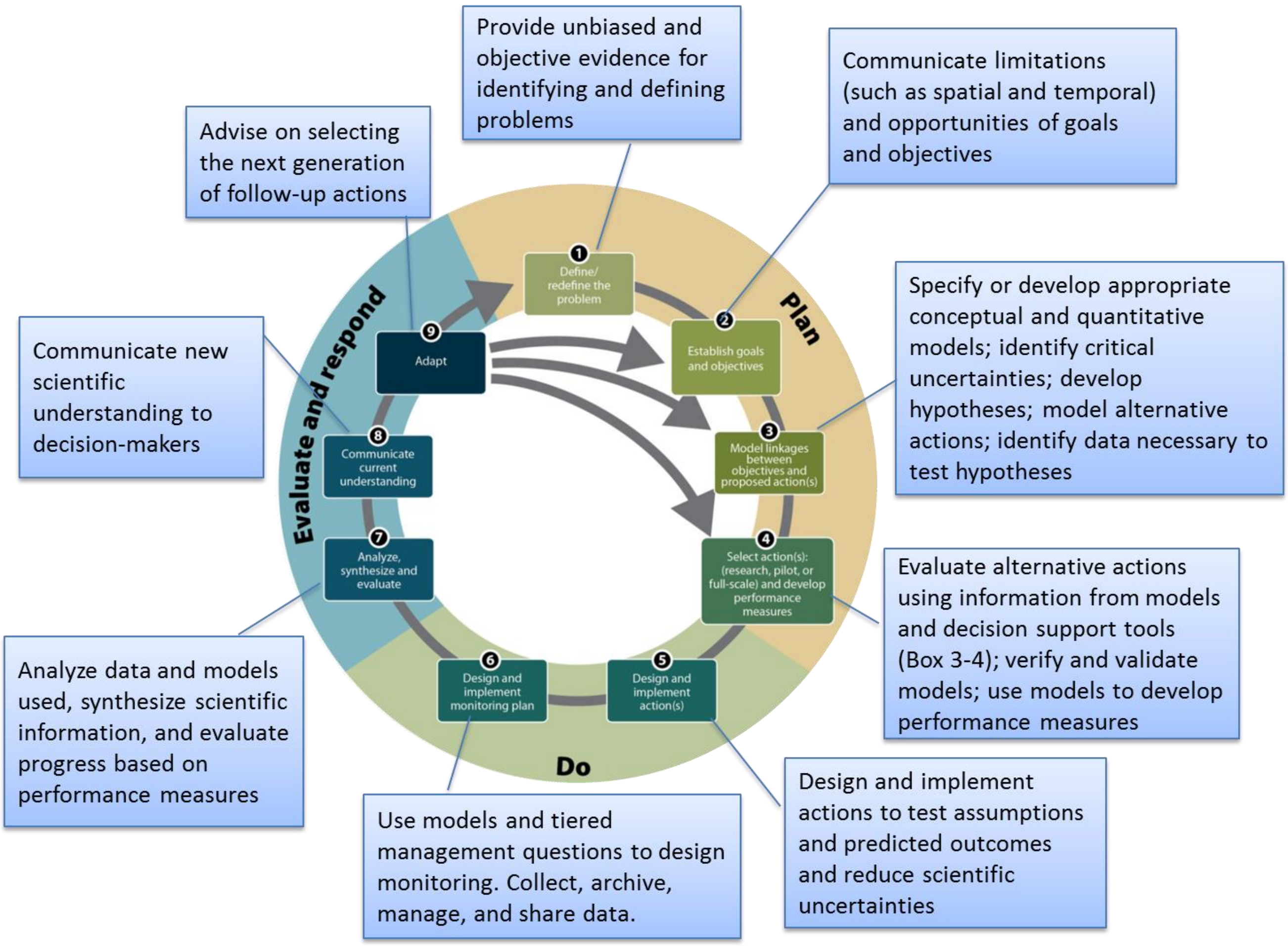

Figure 3-1. Delta Plan's Adaptive Management Framework with the role of science identified in call-out boxes for each step.

Problem Statement

Past attempts to adaptively manage Delta water operations and habitat restoration have rarely covered the full adaptive management cycle, and have not considered the appropriate time frame and spatial scale required for changes to occur as a result of management actions. System-level progress toward achieving the coequal goals will not be possible if multiple adaptive management efforts are incomplete, nonintegrated, fail to consider system-wide and local effects, or are unable to respond within the time frame of management actions.

Objective

- Improve system-wide understanding in the face of uncertainty through water management actions and ecosystem restoration efforts consistent with the Delta Plan adaptive management approach

Actions

3.1 **Provide Adaptive Management Liaisons**

Establish a team of Delta Science Program staff members with expertise in the science needed to advise those engaged in adaptive management. These staff members will provide advice on availability of models, regional monitoring activities, and relevant research, and will help with integrating individual adaptive management projects, plans, and programs across the Delta system. These staff members will serve as Adaptive Management Liaisons to their counterparts in agencies and organizations that are planning and implementing effective adaptive management programs and projects including Delta Plan covered actions [Appendix G].

Primary Responsibility: Delta Science Program

Action Participants: Delta Science Program staff, agencies, and organizations involved in planning and implementing adaptive management

3.2 **Develop and use adaptive management frameworks**

Develop and utilize science-based adaptive management frameworks (Box 3-2) for restoration efforts and water management actions that are consistent with the Delta Plan's adaptive management framework and provide for consistent and integrated regional and system-wide approaches (Box 3-3).

Box 3-2 Attributes of adaptive management frameworks

1. Integration of adaptive management activities to improve nesting of adaptive management projects into landscape-scale efforts, shared learning, and efficient use of resources.
2. Institutional arrangements to sustain scientific assessment and support rapid, nimble, and authoritative management decisions at appropriate time intervals (water operations decisions generally occur at more frequent intervals than habitat restoration decisions).
3. Use of conceptual models including landscape-scale conceptual models for priority restoration areas based on historical ecology and latest science.
4. Emphasis on hypothesis-testing and linkage to companion science programs.
5. Use of broadly accepted and transparent quantitative models to analyze alternative futures (short- and long-term) and address "what if" questions.
6. Expert evaluation and peer review of project design.
7. Monitoring, data management, and evaluation consistent with system-wide efforts and Delta Science Plan recommendations.
8. Focused synthesis and communication of the state of knowledge needed to inform adaptive management decisions.
9. Scientific oversight by the Delta Independent Science Board.

1) The *Restoration Framework* will provide principles for adaptive management of Delta ecosystem restoration actions and will call for developing regional conservation strategies for each of the six priority habitat restoration areas[9]. The Restoration Framework will be developed by the participants in the Delta Conservancy's Delta Restoration Network.
2) A *Water Management Framework* will provide principles for adaptive management. The Delta Science Program will work with ongoing water management efforts such as the Long-term Operations Biological Opinions RPA Implementation and the Collaborative Science and Adaptive Management Program and its Collaborative Adaptive Management Team (CSAMP/CAMT) to develop the Water Management Framework.

Box 3-3 Example Elements of integrated regional and system-wide adaptive management

Habitat Restoration
- Shared landscape-scale conceptual models that incorporate documented landscape functions and processes from historical ecology research (Action 4.4.2)
- Qualitative and quantitative modeling and expert opinion assessment ("DRERIP evaluation") of possible restoration design outcomes (Box 3-4)
- Integrated monitoring to systematically inform adaptive management and report on Delta environmental changes to policymakers and the public (Action 4.2.2)
- Means to compare restoration outcomes to quantifiable goals and performance measures to adjust future management steps if needed

Water Management
- Coordinate real-time water operations of the Central Valley Project/State Water Project with real-time physical and biological data and modeling
- Use an interdisciplinary approach to evaluate "what if" scenarios for optimizing water supply, species protection, and other beneficial uses (e.g., hydropower, agricultural and municipal uses, recreation, and harvest fisheries).

<u>Primary Responsibility</u>: Delta Science Program and Delta Stewardship Council Planning along with (1) Delta Conservancy and its Restoration Network participants; (2) NMFS, USFWS, CDFW, DWR, USBR and other CSAMP/CAMT participants

<u>Action Participants</u>: Agencies and organizations involved in planning and implementing adaptive management

[9] The Delta Plan identifies six priority habitat restoration areas: Yolo Bypass, Cache Slough Complex, Cosumnes River – Mokelumne River Confluence, Lower San Joaquin River Floodplain, Suisun Marsh, Western Delta/Eastern Contra Costa County.

Box 3-4 Decision-support tools for adaptive management

Clearly articulated conceptual models that specify key state variables (e.g., temperature, water volume, population size), describe their dynamic interrelationships, and project consequences of alternative management actions are a key component of adaptive management (Williams et al. 2007, Walters 1986). Models are extremely valuable because they require the author(s) to specify the predicted link between management objectives and proposed actions to clarify how and why each action is expected to contribute to those objectives. They also provide a venue to identify areas of uncertainty, assess the likelihood of success, identify potential restoration or water management actions, develop expectations and performance measures, and define monitoring needs.

The Delta Regional Ecosystem Restoration Implementation Plan (DRERIP) conceptual models were developed for the purpose of showing the characteristics and dynamics of the Delta ecosystem, qualitatively predicting ecosystem and species response to specific changes in ecosystem attributes, and providing the science-based information needed to determine whether a restoration action would result in (or contribute to) a desired management outcome. These models are valuable tools themselves, but were designed to provide information for use in structured assessments of proposed restoration actions through the DRERIP Action Evaluation Procedure and Decision Support Tool (DiGennaro et al. 2012). These models have been used to inform restoration initiatives at Prospect Island and Yolo Ranch [Appendix F]. The Delta Science Program, in collaboration with others, will build upon this tool to water management decisions and make it an integral component of the Water Management Framework.

3.3 Model future scenarios

Model alternative future scenarios and predict system-wide responses using interdisciplinary teams. Alternative scenarios will be developed and explored across the entire Delta, including the six priority restoration areas, and will address the categories of science described in Box 3-5. This will allow finite resources such as water, tidal energy, and sites suitable for restoration of certain ecological functions and a landscape-scale mosaic of habitats to be modeled, thereby identifying opportunities and tradeoffs to inform decisions on ecosystem restoration and water management actions.

BOX 3-5 Categories of science to support achievement of the coequal goals

- **Basic science** to understand the dynamic state of the estuary and how the major stressors (altered hydrology, alterations to the physical landscape, invasive species introductions, and pollutants) affect ecosystem restoration outcomes and water supply reliability.
- **Delta change management** that anticipates step-changes in the shape or state of the contemporary Delta from floods, seismic events, toxic spills, or new introductions of invasive species. This category requires skilled and rapid decision-support for prioritizing and executing responses.
- **Operation of the Delta – from Sierra to the sea** for water supply reliability, flood management, and power benefits. This includes modeling alternative management scenarios for operating the Delta of the future – the one that evolves through both unanticipated events and by design.
- **Restoration** to purposefully change the Delta ecosystem to support conservation of native species at the system-scale. Restoration at the Delta-scale will take decades and continually confound and surprise us. Restoration actions (past, present, and future) will affect one another, and staging restorations to be ecologically relevant is a must.

Primary Responsibility: Delta Science Program

Action Participants: Agencies and organizations that are planning and implementing adaptive management, CWEMF

3.4 **Hold an Annual Adaptive Management Forum**

Hold an annual Adaptive Management Forum with national and international experts and local proponents to provide adaptive management training to build capacity for planning and implementing adaptive management, establish and refine adaptive management frameworks (Action 3.2), share lessons learned from the Delta and elsewhere, and provide a venue in which ecosystem restoration and water management adaptive management activities can be integrated.

Primary Responsibility: Delta Science Program

Action Participants: National and international experts on adaptive management; federal, State and local agencies; non-governmental organizations; private organizations, and academic institutions involved in implementing adaptive management

Expected Outcomes

- Management and policy decision-making processes take advantage of current research, modeling, and monitoring with results that are packaged and communicated effectively. New scientific findings and understanding are incorporated into new and ongoing management actions
- Resources are used efficiently to achieve faster and more effective implementation of water management and ecosystem restoration
- Individual adaptive management programs and plans have greater consistency, facilitating learning, integration of results, and evaluation of cumulative and system-wide benefits
- Critical uncertainties among management alternatives are addressed in an organized and efficient manner that accelerates shared learning for application to future management actions
- Problem formulation, reflection, and continuous learning become institutionalized across agencies and interest groups

4. BUILDING THE INFRASTRUCTURE FOR SCIENCE

"In carrying out this section, the council shall make use of the best available science."[10]

The Delta Reform Act and the Delta Plan require the use of "best available science" in decision-making that affects the achievement of the coequal goals (Box 1-2). The dynamic nature of the scientific enterprise should be recognized and mechanisms for including new knowledge or the latest data should be built into the process where appropriate. The Delta Science Plan pursues science that enables discovery and continuously improves and adds to the body of scientific knowledge. If applied correctly, adaptive management will take advantage of the improving body of scientific knowledge.

This chapter describes the infrastructure necessary to develop the science needed to inform complex decisions surrounding the management of the Delta. Science that informs policy and management decisions is built on a foundation of research, models, monitoring, analysis, synthesis, peer review, and communication (Figure 4-1). At its most basic level, science is built on hypotheses that express ideas about how the world works. In a complex system like the Delta, hypotheses often take the form of conceptual models which can then be applied and tested through analyses and computer models. Models need data that come from research and monitoring results. Synthesized research tells modelers how to improve algorithms that capture our understanding of processes and our ability to predict future conditions. Scientists use data analysis, modeling results, and research findings to synthesize a higher level of understanding about how a system works.

All of these elements are essential to building defensible and transparent science to support current and future decisions about the Delta. The Delta Science Program will work with other programs to further develop and integrate these components. Details on the specific priorities for these elements will be described in the Science Action Agenda (e.g., salmonids life-cycle models and demand forecasting models).

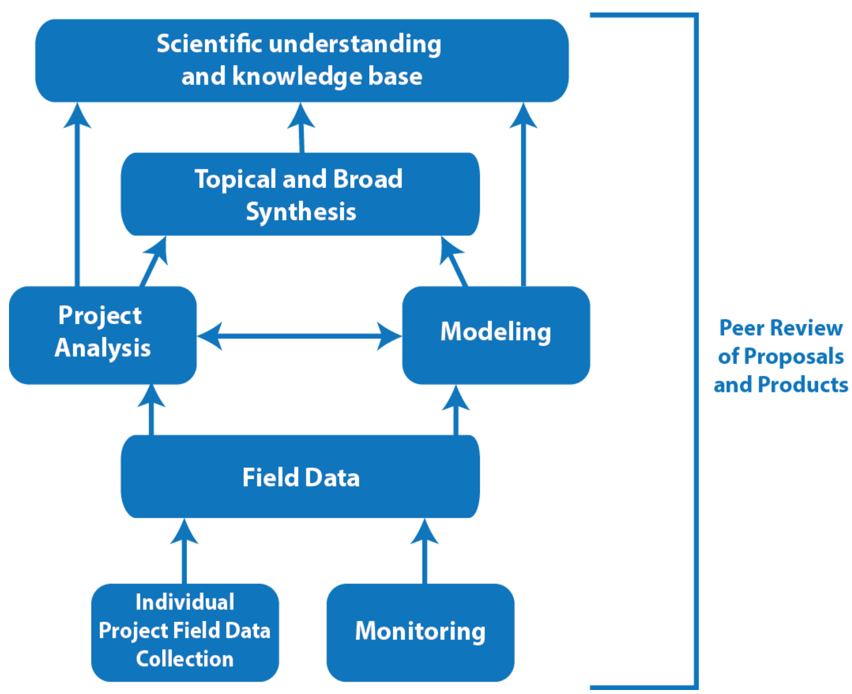

Figure 4-1. Conceptual relationships of the major elements of science infrastructure.

[10] *Water Code §85302(g)*

4.1 Funding research

Research in the Delta is done by universities, federal, State, and local agencies, and private and nonprofit organizations. It ranges in scale from foundational (e.g., analyzing the diet of California clapper rails) to broad (e.g., developing linked models that provide information on discharge, flow paths, and other ecosystem attributes). It is important, however, that research in the Delta address short-term management needs (e.g., what kinds of flow patterns are needed?), fill gaps in knowledge, and develop long-term comprehensive understanding of the Delta ecosystem (e.g., are the cumulative interactions between shallow tidal habitat, invasive species, climate change, and contaminants on the productivity of tidal marshes?). To provide a more comprehensive understanding, research should address immediate needs and the development of understanding of future conditions. This requires stable funding with some support given to explore emerging technologies and innovations that may be risky to implement, but could have a big impact on the current state of scientific knowledge. Providing for these differing needs requires a range of Delta research funding processes.

Efforts to Build On:

- Multi-agency sponsorship of Delta Science Fellows solicitations
- Research needs identified by BDCP
- Delta Science Program Proposal Solicitation Package (PSP) process for identifying research priorities

Problem

There is a continuous need for scientific research to inform Delta decision-making. In addition to research that addresses specific management questions, research that helps to answer basic questions about how the Bay-Delta system works and research that helps train the next generation of scientists is also needed. However, a shared and balanced portfolio of research funding programs and mechanisms that address sustainable short-term and long-term science needs does not exist.

Objective

- Establish a balanced portfolio of research funding programs and mechanisms that provide for sustainable short-term and long-term science needs

Actions

4.1 **Support research**

Competitive research grants - The Delta Science Program will manage and provide independent scientific peer review for a jointly-funded solicitation process for selecting research projects. Proposals will be assessed on intellectual merit (provided by anonymous external reviewers and review panels) and their potential contribution to the body of scientific knowledge needed to make management decisions. Proposal funding partners will make funding decisions based on their program priorities.

Delta Science Fellows - The Delta Science Program and California Sea Grant will jointly manage an annual Delta Science Fellows solicitation with potential research topics and funding invited from other organizations. The selection will be based on intellectual merit (provided by anonymous independent peer review and science review panels) and contributions to the body of scientific knowledge needed to make Delta ecosystem restoration and water management decisions.

Rapid-response research grants - To maintain flexibility and responsiveness of Delta science, some research funds will be set aside for opportunistic research and/or to address unexpected events such as a major flood, earthquake, levee failure, or salt-water intrusion into the Delta. These time-sensitive, innovative, or exploratory research ideas will be managed similar to the National Science Foundation's Rapid Response Research (RAPID) or Early-concept Grants for Exploratory Research (EAGER) grants. They will be funded through: a) focused solicitations where the scope of a project is generally known but it is open for proposals, or b) directed actions where the scope of the project is well-defined and the appropriate project team has been identified for example, due to ongoing activities.

Primary Responsibility: Delta Science Program

Action Participants: IEP, BDCP, ERP, SFCWA, and other science programs of federal, State, and local agencies, and NGOs

Expected Outcomes

- Research is prioritized and funded efficiently
- The capacity to conduct high-priority research is expanded

4.2 Monitoring and associated research

Environmental monitoring provides important scientific information that helps policymakers, managers, and the public address challenging environmental issues. The term "monitoring" covers a wide variety of sampling, analysis, measurement, and survey activities. A comprehensive Delta monitoring program would follow environmental change as policy and management decisions are implemented and provide information to support adaptive management. It should include information about water supply, the ecosystem, and the Delta as place.

In the Delta, environmental monitoring has long played an important role and many long-term monitoring programs exist. For example, the Interagency Ecological Program (IEP) has been monitoring various kinds of fishes and ecological parameters (e.g., water flow, water quality, phytoplankton, zooplankton, benthic invertebrates) for decades. Additional programs soon will be added, such as the Delta Regional Monitoring Program and key monitoring elements as part of the BDCP, if approved. Both programs are currently under development. However, none of the existing and planned programs capture or coordinate Delta monitoring

Efforts to Build On:

- Current and emerging regional monitoring programs
  - Delta Regional Monitoring Program
  - Regional Monitoring Program for San Francisco Bay (includes Suisun)
  - Interagency Ecological Program
- Delta Independent Science Board periodic reviews of monitoring programs that support adaptive management of the Delta
- Monitoring frameworks
  - UMARP framework (Luoma at al. 2010)
  - CWQMC California Estuaries Portal (CWQMC 2013)

in the comprehensive manner needed to support the Delta Plan, BDCP, or other plans, programs, and regulatory requirements. While a statewide strategy for water quality monitoring exists (CQWQMC 2010), a Delta monitoring strategy that builds on existing frameworks, such as UMARP, has not yet been developed. The Delta Science Plan proposes the development of a comprehensive monitoring strategy that will allow for better design, coordination, and integration of all monitoring components that track stressor reduction and restoration outcomes (see also Chapter 3 – Adaptive management for a complex system). This strategy would be based on a common monitoring framework and would build on recent efforts sponsored by the Delta Science Program, CWQMC, and others. Inherent to this monitoring framework is the appropriate and timely assessment, reporting, and publication of monitoring results.

Problem

A shared strategy for integrated monitoring to address Delta ecosystem and water management needs does not exist. Monitoring needs span a wide range of topics and data types from precipitation, runoff, stream flow, land use, contaminant inputs, and vegetation to fish abundance and distribution, all with a geographic range that goes from the headwaters of Sierra Nevada streams to the Pacific Ocean.

Objectives

- Expand, consolidate, and sustain existing web-based inventories of monitoring efforts in the Delta and its associated watershed.
- Develop a comprehensive Delta monitoring strategy
- Integrate and improve monitoring programs and fill-in high priority monitoring gaps to provide the information needed for Delta water management and ecosystem restoration decisions

Actions

4.2.1 **Support and sustain a web-based information system for monitoring activities**

Make monitoring information more accessible by supporting and sustaining a web-based information system, such as the Central Valley Monitoring Directory, that describes monitoring activities in the Delta, their products, and nexus to regulatory requirements and management actions.

Primary Responsibility: CWQMC, IEP

Action Participants: Delta Science Program, statewide, regional, and local monitoring programs

4.2.2 **Build a comprehensive Delta monitoring strategy and program**

Use the strategy to develop an integrated Delta monitoring program with a shared purpose to systematically inform adaptive management of multiple stressors on the ecosystem and report on Delta environmental changes to policymakers and the public.

Primary Responsibility: Delta Science Program

Action Participants: Delta Regional Monitoring Steering Committee, IEP, CWQMC, BDCP, and federal, State, and local agencies, NGOs

Expected Outcomes

- Development of a collaborative and comprehensive monitoring strategy based on clear conceptual models
- Regular monitoring information feedback for adaptive management
- Improved availability of data for assessing outcomes of water quality protection, water and land management, and habitat restoration actions
- Improved availability of data for use in regulatory oversight

See Also

- Section 4.3, Data management and accessibility, for information about data interoperability
- Section 4.7, Communication, for information about making monitoring information available online

4.3 Data management and accessibility

"One of the greatest challenges for 21st-century science is how we respond to this new era of data-intensive science. This is recognized as a new paradigm beyond experimental and theoretical research and computer simulations of natural phenomena—one that requires new tools, techniques, and ways of working."[11]

During the last decade, the collection and analysis of environmental data has increased exponentially for many purposes including: regulatory compliance, research to understand fundamental landscape-scale processes and trends, and assessing the effectiveness of mitigation and restoration efforts. Improved data sharing, accessibility and analytical tools, deploying new sensor technologies, and coordinated research networks will support the use of process-based analytical models and accelerate new insights. Data integration and management are critical components of robust adaptive management goals to achieve improved availability of data for use in regulatory and policy development programs.

Science programs, agencies, and researchers collect data designed to meet their respective requirements, mandates or questions. Globally, the emerging era of 'Big Data' is transforming how science is conducted (*Science*, February 11, 2011), but data are only useful when they can be accessed, analyzed, and transformed into knowledge.

Efforts to Build On:

- California Technology Agency (http://www.cio.ca.gov/)
- Water Quality Monitoring Council, My Water Quality (http://www.MyWaterQuality.ca.gov)
- National initiatives, for example: DataONE http://www.dataone.org/

[11] Douglas Kell, University of Manchester, on *The Fourth Paradigm: Data-Intensive Scientific Discovery* (http://research.microsoft.com/en-us/collaboration/fourthparadigm/)

Problem Statement

Currently, it is difficult to know what data are being collected, the quality of the data, and how the data can be accessed and queried. This makes it difficult to conduct synthesis activities that are comprehensive and reproducible without a major investment of time and resources. This is a major obstacle for scientists working on critical Delta issues. Collaborative science and data synthesis will continue to be constrained unless there is a commitment to build an open community of science with data sharing agreements, interoperability standards, and the documentation to correctly interpret the data. Additional resources are needed to build and sustain the infrastructure necessary so that existing databases can communicate with each other.

Objective

- Build on existing and emerging data management systems to enable the Bay-Delta region's environmental and project-implementation data to be easily accessed, visualized, and processed from diverse data management systems by agencies, scientists, interested public, academia, and 'citizen scientists' (including K-12 schools) resulting in enhanced discovery and accumulation of knowledge.

Actions

4.3.1 **Host a data summit**

Host a data summit to explore and identify needed improvements to cyber-infrastructure, data management capacity, and mechanisms to facilitate active data sharing, data mining, and analysis. Information generated in the Summit will inform the Science Action Agenda, support innovations in data integration and management, and develop paths for enhancing and sustaining current initiatives.

<u>Primary Responsibility</u>: Delta Science Program, CWQMC, California Technology Agency, and other key partners

<u>Action Participants</u>: Delta Conservancy, USGS, NMFS, BDCP, IEP, CAMT, and other agencies and programs responsible for managing environmental data related to the Delta, as well as representatives from universities, consultants, NGOs, and invited experts in the field of data management

4.3.2 **Develop guidelines for data sharing**

Based on outcomes from the Summit, guidelines for data sharing will be developed including criteria for metadata and descriptions of existing or needed web services for enabling community data access, integration, visualization, and display.

<u>Primary Responsibility</u>: Delta Science Program, CWQMC, California Technology Agency, and other key partners

Action Participants: Delta Conservancy, USGS, NMFS, BDCP, IEP, CAMT, and other agencies and programs responsible for managing environmental data related to the Delta, as well as representatives from universities, consultants, NGOs, and invited experts in the field of data management

Expected Outcomes

- Enhanced data sharing among agencies, institutions, and other disciplines
- Web services enabling community data access, integration, analysis, and visualization
- Open access data for researchers, agencies, scientists, stakeholders, academia, and citizen scientists (including K-12 schools), with clear metadata protocols that include descriptions of accuracy estimates and the level of quality control applied to the data set
- Timely integration of emerging technologies to access and assimilate real-time data and drive models.

4.4 Shared modeling

"Models can be used to develop insights, often in a transparent, visual, and defensible manner. Models are needed for adaptive management and planning. They summarize and integrate our understanding of systems and processes with greater precision and transparency."[12]

A new era is emerging of open computer codes, cloud computing, data accessibility, data visualization, and virtual networks of scientists supporting and advancing models. The Delta modeling community embraces these changes and seeks to be at the forefront of developments for addressing environmental issues. Models will continue to be a central part of our understanding of how the Delta functions as a system and be a key component in the design, management, and performance assessment of projects and actions (Box 4-1).

The Bay-Delta system is a complex and dynamic system and the potential massive scale of forced changes due to restoration projects, changes in water operations, new invasive species, climate change or natural disasters will mean that we can

Efforts to Build On:

California Water and Environmental Modeling Forum – The CWEMF mission is to increase the usefulness of models for analyzing California's water-related problems. CWEMF carries out this mission by:

- Facilitating an open exchange of information on California water issues;
- Resolving technical disagreements in a non-adversarial setting; and
- Ensuring that technical work continues to take into account the needs of stakeholders and decision-makers.

Since 1994, CWEMF has initiated and managed a number of impartial peer reviews. These peer reviews:

- Document model strengths and weaknesses
- Suggest improvements
- Assess the suitability for intended applications

CWEMF has helped build the modeling community by bringing modelers together from California and across the country at its annual meetings.

[12] Delta Science Program Invited Panel, 2012.

no longer rely on past records to predict future conditions. Modeling is critical to explore and communicate alternative future conditions for the Delta depending on the management options selected. These models must be transparent with a clear understanding of the expected uncertainty in predictions.

> **Box 4-1 The importance of models**
>
> Modeling is an essential and inseparable part of all scientific, and indeed all intellectual, activity… the professional modeler brings special skills and techniques to bear in order to produce results that are insightful, reliable, and useful… such as sophisticated statistical methods, computer simulation, systems identification, and sensitivity analysis. These are valuable tools, but they are not as important as the ability to understand the underlying dynamics of a complex system well enough to assess whether the assumptions of a model are correct and complete.
>
> Above all, the successful modeler must be able to recognize whether a model reflects reality, and to identify and deal with divergences between theory and data. (Silvert 2001)

Problem

Modeling takes place at many agencies, academic institutions and private entities that are often pursuing different questions. Even when using the same model, different conclusions can be drawn due to different scenarios, assumptions or the data used by individual modelers. Further, it is difficult to exchange information between the discipline-specific models necessary to address many contemporary questions. Modeling needs to be done in a more interdisciplinary and collaborative way to accelerate new understanding, avoid duplication of efforts, and support diverse modeling approaches.

Objectives

- Accelerate new understanding about how the Delta system functions through development of a mechanism that supports models used for today's management actions, while researching and testing models for the future
- Establish community models that are accessible, transparent, sustained by multiple sources and encapsulate the current knowledge of the Delta system
- Provide managers with predictions of likely outcomes resulting from management actions
- Use these models to articulate different futures for the Delta depending on the management decisions made

Actions

4.4.1 **Develop a collaborative community modeling framework**

Develop a framework for collaborative community modeling (Box 4-3) to enhance

> **Box 4-3 Community Modeling Example**
>
> The Community Surface Dynamics Modeling System housed at the University of Colorado is "a virtual home for a vibrant and growing community of about 1,000 international modeling experts and students who study the dynamic interactions of lithosphere, hydrosphere, cryosphere, and atmosphere at Earth's surface. Participating in cross-disciplinary groups, members develop integrated software modules that predict the movement of water, sediment, and nutrients across landscapes and into the ocean." It includes an open library of models, software, and access to high-performance computing.

interdisciplinary modeling, accelerate new understanding, avoid duplication of efforts, and support diverse modeling approaches. This framework will be based around the four science needs shown in Box 3-5 and will be developed through a Modeling Summit co-hosted by CWEMF and the Delta Science Program. At this summit, alternatives for managing and sustaining the framework will be explored and recommendations for the ecosystem of the Bay-Delta and its watershed will be made.

Primary Responsibility: Coordination by Delta Science Program, with key roles for CWEMF (4.4.1 and 4.4.4) and ERP (4.4.2)

Action Participants: DWR, BDCP, CAMT, IEP, SWRCB, agencies, academics, consultants

4.4.2 **Develop, update, and maintain conceptual models**

Develop, update, and maintain conceptual models to identify the current state of knowledge, identify gaps in understanding, contribute to the identification of research priorities, and support adaptive management planning and implementation. The Delta Science Program will track and help promote the use of these conceptual models in guiding Delta management, including landscape-scale conceptual models for the six priority ecosystem restoration areas identified in the Delta Plan.

Primary Responsibility: Coordination by Delta Science Program, with key roles for CWEMF (4.4.1 and 4.4.4) and ERP

Action Participants: DWR, BDCP, CAMT, IEP, SWRCB, agencies, academics, consultants

4.4.3 **Support high-priority model development**

Support high-priority model development and refinement through research grants, fellowships, workshops, seminars, and conferences. Foster the development of inter-institutional and interdisciplinary clusters of scientists around model themes (as in the CASCaDE project). Ensure a continuity of support for these initiatives to sustain model development and technical support to the broader scientific community.

Primary Responsibility: Coordination by Delta Science Program, with key roles for CWEMF (4.4.1 and 4.4.4) and ERP (4.4.2)

Action Participants: DWR, BDCP, CAMT, IEP, SWRCB, agencies, academics, consultants

4.4.4 **Embrace alternative modeling approaches**

Embrace alternative modeling approaches and support inter-model comparisons to help quantify uncertainty and sensitivity arising from different assumptions, quality and quantity of available data, different algorithms or alternative scenarios.

Primary Responsibility: Coordination by Delta Science Program, with key roles for CWEMF (4.4.1 and 4.4.4) and ERP (4.4.2)

Action Participants: DWR, BDCP, CAMT, IEP, SWRCB, agencies, academics, consultants

Expected Outcomes

- Enhanced collaborative activities between modelers, shared input data, shared scenarios and results, data streaming between different models, and a modeling community that is at the forefront of predicting the outcomes of alternative water and environmental management scenarios
- Accelerate the transfer of best available science to inform management actions in support of water supply reliability and the Delta ecosystem
- Apply emerging visualization, virtualization, and gaming technologies to assist communication of scientific results and projected alternative Delta future conditions
- Reduce the resources required for initial model set-up and application, thereby increasing the time and resources modelers have available to conduct synthesis, interpretation, uncertainty analyses, information transfer, improvement of model algorithms, and development of the next generation of models to address Delta issues

4.5 Synthesis for system-wide perspectives

The central challenge in understanding a system as large and complex as the Delta is integrating information about the components into a coherent whole. Decades of research and monitoring have yielded tremendous volumes of data, but too often, appropriate methods to integrate across multiple data sources are lacking. The financial resources required to meet this mandate have yet to be agreed upon and allocated (See Chapter 5). Synthesis activities must become a high priority if the current culture of selectively using data to support special interest viewpoints is to change. Leadership and mechanisms for bringing together researchers from agency, stakeholder and academic communities are needed to foster scientific synthesis for two major reasons: (1) New knowledge gained from synthesis activities will inform the design and evaluation of alternative management and operational strategies, thereby facilitating management decisions that will lead to improved outcomes, (2) Synthesis is an important component in resolving scientific conflict over data interpretation; the appropriate synthesis mechanisms should be chosen relative to the urgency in which decisions need to be made (e.g., white papers, workshop summaries, journal publications, books, web content, etc.)

Efforts to Build On:

- *The State of Bay-Delta Science 2008*
- Synthesis products in *San Francisco Estuary and Watershed Science*
- National Center for Ecological Analysis and Synthesis model
- IEP Pelagic Organism Decline
- Delta Science Program Workshops
- IEP Management Analysis and Synthesis Team
- California Estuaries Portal, California Wetlands Portal, EcoAtlas, and Integrative Health of the Estuary Web Tools.
- California Estuaries Portal, California Wetlands Portal, EcoAtlas, and Integrative Health of the Estuary Web Tools.

Problem

Synthesis is the single most important need for developing Delta science (NRC 2012) and identifying the likely consequences of management actions. Without mechanisms, protocols, and resources for conducting ongoing synthesis, new insights, and better understanding vital for the health of the Delta ecosystem will be hindered or obstructed.

Objectives

- Provide timely support for policy and management decisions
- Promote and support the practice of data analysis and synthesis in the Delta science community

Actions

4.5.1 **Foster integrative synthetic thinking throughout the Delta science and management communities**

Provide forums and collaborative initiatives (e.g., Policy-Science Forum (Action 2.1) and focused science synthesis (Action 2.5)) as training and information exchange opportunities for science and engineering staff within regulatory and management agencies. These opportunities will allow staff to be integrative and develop “system-thinking” such that they become accustomed to habitually considering the larger context and linkages that go beyond the statutory boundaries of their respective agencies. This can be achieved via a combination of:

1) Actions described in Chapter 2 that are characteristic of “boundary organizations” that operate in both scientific and practical spheres (e.g., Delta Science Program, Public Policy Institute of California; Sustainable Conservation; SFEI-ASC, Pt. Blue Conservation Science), and that facilitate communication between scientists and decision-makers
2) Embedding research scientists within regulatory or resource management agencies to help fill high-priority knowledge gaps
3) Strengthening links through formal agreements, as listed in Action 4.1, between resource managers and scientists at research-focused institutions (e.g., Science Fellows)
4) Train resource management professionals directly via workshops, seminars, conferences, fellowships, and limited-term “rotator” positions with the Delta Science Program (see Chapter 5) to enable them to operate in both spheres of decision-making and science.

Primary Responsibility: Delta Science Program

Action Participants: IEP; BDCP; SWRCB; and other federal, State, and local agencies; academic institutions; California Sea Grant

4.5.2 Establish mechanisms and protocols for ongoing synthesis

Establish mechanisms and protocols for conducting ongoing syntheses to accelerate understanding of the Delta, to manage scientific conflict through shared processes, and to support policy and management decisions. Four mechanisms are:

1) Invited white papers/journal articles by small groups of authors
2) Expert workshop panels similar to the CALFED Science Program Ammonia/Ammonium Workshop [Appendix H]
3) Delta Collaborative Analysis and Synthesis (DCAS) – Focused teams with regional and national interdisciplinary experts that conduct in-depth analyses over a period of one year resulting in peer-reviewed journal articles or white-papers that summarize current knowledge or bring fresh perspectives to a major issue
4) *The State of Bay-Delta Science* updates.

Primary Responsibility: Delta Science Program

Action Participants: IEP; BDCP; SWRCB; and other federal, State, and local agencies

Expected Outcomes

- Accelerated understanding about the state of the Delta ecosystem
- Diverse synthesis publications including SBDS, scientific journals articles (e.g., articles in San Francisco Estuary and Watershed Science), Delta Science Program White Papers, and synthesis papers resulting from CABA seminars.
- A culture of interdisciplinary and collaborative scientific exploration that enhances the understanding of a dynamic system
- A better understanding about how the Delta responds to change induced by management actions, climate change, natural disasters and chronic stressors

4.6 Independent scientific peer review and advice

Making well-informed decisions regarding the use and protection of natural resources requires that we fully consider and employ the most reliable and accurate scientific information and judgment available. Calls for inclusion of "the best available science" and independent analyses or review of environmental policy and decision making repeatedly are heard from Congress, the Executive Branch, and other interests. We agree that such participation by the nation's scientific community in the form of independent scientific review can contribute to better-informed environmental policy and decision making.'[13]

The peer review process uses independent scientific experts and plays a key role in determining what "best available science." is Peer review increases the credibility of scientific information and helps scientists improve the quality of their work. Peer review should be an integral and expected part of the

[13] Gary K. Meffe, P. Dee Boersma, Dennis D. Murphy, Barry R. Noon, H. Ronald Pulliam, Michaele E. Soule and Donald M. Waller. Independent Scientific Review in Natural Resource Management. Conservation Biology Volume 12, No. 2, April 1998

science conducted in the Delta. A culture of constructive ideas and innovation to improve the quality and applicability of science should be fostered. The Delta Science Program's policy and procedures for independent peer review of processes, programs, plans, and products are included in Appendix I. Peer review is also a key part of research grant funding programs. In addition to providing feedback on scientific integrity, well-designed peer review processes provide independent perspectives and judgments from experts in the subject area. To be most effective, high-quality peer reviews should be conducted in a way that is objective, rigorous, and transparent.

A companion to peer review is independent scientific advice. Projects and programs often benefit from the active participation of an independent scientist or scientists when they are faced with challenging technical or scientific issues. In these cases, an independent entity can help by identifying experts with experience in the appropriate disciplines who can provide advice at key points in planning, implementation, or evaluation.

Efforts to Build On:

- Draft Delta Science Program Policy and Procedures for Independent Scientific Review (February 2013)
- Delta Science Program Proposal Solicitation Package review process
- National Academies' review approach and role
- Delta Independent Science Board reviews

Scientific peer review or advice can be set up in several ways. The entity conducting the review, number of reviewers, the type of process (e.g. panel meeting, independent written reviews), and the length of time for the review can all be adjusted to fit the complexity, level of scientific uncertainty, importance of the subject, and available funding. In its broadest sense, peer review includes the review functions of the Delta Science Program, the Delta Independent Science Board and the National Research Council. The Delta Science Program will take a leadership role in the review of proposals, processes, programs, plans, and products (Figure 4.6-1). Reviews may be conducted in-house organized by Delta Science Program staff or by other agencies or institutions with Delta Science Program tracking and guidance. The Delta Independent Science Board's review responsibilities are defined in statute and include periodic reviews of the "scientific research, monitoring, and assessment programs that support adaptive management of the Delta" (Water Code §85280 (a)(3)). Upon request, the National Research Council may be asked to review issues with broad implications for federal agencies or of importance to restoration or water management efforts.

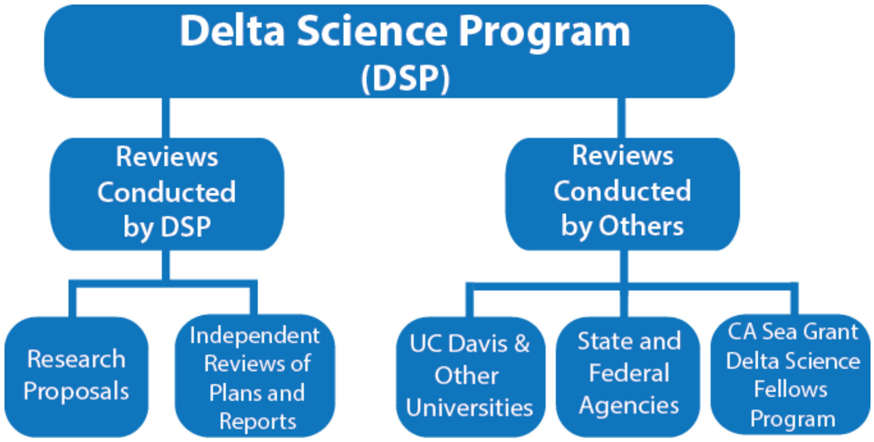

Figure 4.6-1 Structure of reviews conducted under the Delta Science Plan.

Problem

Research reports and science-based planning and management documents are often used in decision-making even when they have not undergone an effective process of scientific peer review. Such reports and documents may include information that is misleading or inaccurate. Decision-makers and environmental managers require peer-reviewed, defensible, robust science for managing the Delta resources; however, a standard level of peer review is not yet consistently applied in the Delta.

Objectives

- Clearly document independent scientific peer review and advice processes that are consistently applied
- Make thorough and thoughtful changes to reports and documents used in decision-making in response to peer review comments

Actions

4.6.1 Seek broad support and use of a standard process for conducting scientific peer review

Seek broad support and use of a well-defined, transparent, and widely accepted process for conducting scientific peer review that is consistent across programs and can be applied to research, planning, and management documents in the Delta.

Primary Responsibility: Delta Science Program

Action Participants: Federal, State, and local agencies; NGOs, stakeholders, and universities

4.6.2 Develop a response mechanism to scientific peer review

Develop a response mechanism to scientific peer review of programs, reports or actions that address each major point in the review, how the concern is being addressed, and the reasons for not being able to address any issue.

Primary Responsibility: Delta Science Program

Action Participants: Federal, State, and local agencies; NGOs, stakeholders

Expected Outcomes

- Widely-used, transparent peer review and advice processes
- High quality scientific information that builds trust in decision-making processes

4.7 Communication

Communication is essential to building the Delta science community, building understanding of the issues, and delivering important science messages to the public, managers, policymakers, and stakeholders. In fact, it is the keystone for transforming information into knowledge, and knowledge into action. Communication takes many forms from various digital media, publications, news articles, seminars, workshops, and conferences to water cooler conversations. The concept of "best available science" is predicated on the way that scientific information is reviewed and communicated. No matter how important, scientific information that is not communicated is not "available". This section addresses how scientists communicate with each other, and with managers, policymakers, and the public.

A broad range of avenues exists for science communication including seminars, the biennial Bay-Delta Science and State of the Estuary conferences, the Delta Science Program's *Science News* newsletter, the *San Francisco Estuary and Watershed Science* online journal, and the internet. However, the world of communication is dynamic and continually offering new opportunities for improving the way scientists speak to each other and the world.

Efforts to Build On:

- Delta Science Program's *Science News*
- *San Francisco Estuary and Watershed Science*
- IEP's online calendar (http://www.water.ca.gov/iep/activities/calendar.cfm)
- *Pulse of the Delta*
- *Pulse of the Estuary*
- *My Water Quality*
- IAHR – Rivers-list (http://riverslist.iahr.org/)
- *The State of Bay-Delta Science*
- Bay-Delta Science Conference
- State of the Estuary Conference
- *Estuary News*

Problem Statement

Important scientific information is often underutilized because it is not effectively communicated. Better science communication is needed to effectively inform policy and management decisions and to build the Delta science community.

Objectives

- Improve communication of science to the public, managers, and policymakers, and within the science community through current communication mechanisms and the development and application of innovative communication tools
- Exchange new scientific information and its implications with scientists, policymakers, and managers on a regular basis
- Develop and implement programs that are targeted at the broader public and K-12 to enhance their understanding of complex scientific issues in the Delta

Action

4.7.1 **Develop and implement a communication strategy**

Develop and implement a broad-based communication strategy that makes use of a range of media and communications tools [Appendix J].

Primary Responsibility: Delta Science Program

Action Participants: Communication experts, IEP, BDCP, Ecosystem Restoration Program, CWQMC and its workgroups, SFCWA and other science programs of federal, State, and local agencies, State legislature

4.7.2 **Develop and maintain a new website**

Develop a website that will be the central location for Delta science on the Internet. The best scientific and educational information that is available will be aggregated and organized making it accessible to scientists, policymakers, the general public, and grades K-12.

Primary Responsibility: Delta Science Program

Action Participants: Web developer, IEP, BDCP, Ecosystem Restoration Program, CWQMC and its workgroups, SFCWA and other science programs of federal, State, and local agencies, State legislature

Expected Outcomes

- Enhanced Delta science communication among scientists, decision-makers and policymakers and the public so that policy and management decisions are informed by the most up-to-date scientific information
- Improved access to scientific information so that scientists working in the Delta are better informed
- Increased availability of scientific information in formats readily accessible to the non-scientist

See Also

- Chapter 2, Organizing science to inform policy and management
- Section 4.5, Synthesis for system-wide perspectives

5. RESOURCES TO IMPLEMENT THE DELTA SCIENCE PLAN

For decades, substantial resources have been dedicated to conduct monitoring and research resulting in a considerable accumulation of knowledge on the status of endangered species, flow characteristics throughout the Delta, and the potential effects of climate change (NRC 2012). However, as the National Research Council stated (NRC 2012), the integration of science needed to address multiple stressors on the ecosystem is lacking, and insufficient resources are pooled to focus on overarching and often controversial questions common to multiple agencies, but outside the jurisdictional boundaries of any single one. In addition, although the Interagency Ecological Program has had success in coordinating research, monitoring, and modeling activities among their nine participating State and federal agencies, science coordination efforts among agencies with different cultures have proven inefficient, especially for funding science, as identified in a recent report by the Public Policy Institute of California (Gray et al. 2013).

The Delta Independent Science Board pointed out that the Delta Science Plan is faced by a rare opportunity to catalyze transformation of the prevailing "…legal, institutional, and cultural inertia in the system…" that tends to promote business as usual. The Board suggested a range of incentives that could, if applied strategically, transform the *status quo*, starting with the most basic prerequisite – providing adequate and sustainable funding to develop the scientific knowledge needed to inform management decisions. These incentives include in order of potential impact (Delta Independent Science Board 2013):

- Provide regulatory and legal incentives
- Link existing and future State and federal funding to science-based decision-making based on adaptive management principles
- Use the bully pulpit of the Delta Stewardship Council
- Generate momentum through positive examples of joint agency budgeting and resource allocation for science

The Delta Science Plan calls for bringing together the key players who can evaluate science-based solutions to address interactive effects of multiple stressors on the ecosystem and water supply reliability, for generating scientifically based projections of the consequences of actions taken, and for finding science-based solutions to meet often conflicting goals. As the experience of CWQMC and its workgroups has shown, adequate resources are essential in fostering and maintaining collaboration among individual agencies and organizational programs and in being able to build the underlying foundation for reducing uncertainties (see Chapter 4). This includes the infrastructure to share scientific data and information among multiple users. In fact, without this infrastructure, the integration of information to address multiple stressors and evaluate likely outcomes of a range of management actions becomes impossible.

It will take a joint effort by the scientific community to find partnerships and support to build the resource capacity needed to implement strategic directions outlined in the Delta Science Plan and earlier science planning documents (e.g., Vance 2005; CalEPA Steering Committee for Science 2007; Ocean Science Trust 2008; California Water Quality Monitoring Council 2008). Champions are needed in the legislature, Governor's Office, and control agencies to advance the capacity of scientists working in agencies (Box 5-1). The science and management communities together will need to dedicate considerable effort to communicate to funding decision-makers about how relatively small, yet sustainable investments in science can generate disproportionately larger paybacks in terms of operational efficiencies, less litigation, and better environmental and social outcomes. Improvements in the science infrastructure are required to access even the most basic tools required by scientists to inform the multibillion dollar effort to achieve the coequal goals. Without the essential tools and resources necessary to conduct the science, it is far from assured that the investments placed in achieving the outcomes envisioned in the Delta Plan and other major planning efforts to achieve the coequal goals will come to fruition. The science planning documents referenced above are consistent in their recommendations and apply to this day:

- Increase the ability to recruit, retain, and equitably remunerate scientists
- Provide scientists with access to continuing professional development opportunities, such as to scientific journals, up-to-date hardware and software, and national professional conferences and forums for idea exchanges
- Improve linkages and opportunities for interactions between academia and science serving specific ecosystem and water management needs (e.g., research partnerships, professional networks)

Implementing the Delta Science Plan will require strong leadership from the Delta Science Program. To fulfill this leadership role, the Delta Science Program will need to expand its capacity to facilitate and coordinate actions. This will include the ability to supplement core career staff with 'rotators' modeled on the National Science Foundation, whereby scientists from other organizations (including federal

Box 5-1 Building Capacity

Formidable systemic hurdles exist in building the infrastructure for science. Without the essential tools and resources necessary to conduct the science, it is far from assured that the investments placed in achieving the outcomes envisioned in the Delta Plan and other major planning efforts to achieve the coequal goals will come to fruition. The Delta Science Program will work with others to assess possible mechanisms for enhancing:

- The ability to recruit and retain the next generation of scientists
- Career-tracks for scientists in government
- Access to continuing professional development opportunities, national professional conferences, and forums for idea exchanges
- Access to basic scientific tools such as scientific journals, up-to-date hardware and software, the role of universities in supporting science, modeling and professional development of scientists throughout the Delta Science Community (agencies, stakeholders, local government, and consultants)

agencies, State agencies, local government, universities, stakeholders, and non-governmental organizations) may spend a fixed term within the Delta Science Program to help implement the Action Agenda, coordinate updates to *SBDS*, coordinate workshops and peer review activities, or participate in other responsibilities of the Delta Science Program. The salaries of rotators may be covered by the Delta Science Program during the period of appointment. The use of rotators will ensure a continuous infusion of new ideas, ensure the staff that facilitates '*One Delta, One Science*' are representative of the community that the Delta Science Program serves, and build trust that the processes used are open and transparent.

The urgency associated with transforming business as usual makes it imperative that funding for management-relevant research, monitoring, modeling, information management, and development of effective decision-support mechanisms is commensurate with the hundreds of millions of dollars at stake every year associated with water management actions and the success of large-scale restoration activities. Because the requirements for science input into developing "alternative futures" that scientists, policymakers, managers, and the taxpayer can jointly evaluate cannot be accurately anticipated, we propose that 5-10 percent of the value of investments made should be dedicated to reducing scientific uncertainties in the outcomes of those investments. For example, the information required for determining the range of water exports of plus or minus 900,000 acre-feet per year with an approximate value of $270M will be different under various restoration and watershed management scenarios (which may recover valued ecosystem components or increase yield) than the information required to address uncertainties in above- and below-ground storage outcomes. Indexing the resources dedicated to science required to inform the achievement of the coequal goals to the value of water at stake would result in $14-27M per year for science dedicated to reducing the risk of losing investments in ecosystem services, such as water supply reliability, agricultural productivity, clean water, and ecosystem resilience.

Problem Statement

Insufficient resources are pooled to focus on overarching and often controversial questions common to multiple agencies, but outside the jurisdictional boundaries of any single one. Without the essential tools and resources necessary to conduct the science, particularly synthesis activities (NRC 2012), it is far from assured that the investments placed in achieving the outcomes envisioned in the Delta Plan and other major planning efforts to achieve the coequal goals will be successful.

Objectives

- Effectively involve the federal and State Agency directors, Delta Independent Science Board, and the Delta Stewardship Council to catalyze the needed culture change in both the science and management communities.
- Generate an appropriate funding base for fulfilling the vision of an open Delta science community that builds a shared state of knowledge with the capacity to adapt and inform future water and environmental decisions. This funding should include flexibility for innovation and responsiveness to issues such as natural disasters or new invasive species.
- Improve the organizational structure for science and create funding efficiencies via pooled resources to address questions beyond the limited mandates of individual agencies.

- Reform the underlying capacity challenges to conduct science for ecosystem and water management, such as the ability to recruit and retain scientists into State service, as well as providing them with the essential tools required to fulfill their duties.
- Apply a mix of sustainable funding mechanisms for science that supports the science at a scale commensurate with the challenges and the level of activities being conducted for water supply reliability, ecosystem restoration, and flood risk reduction. This is particularly critical for implementation of adaptive management.

Actions

5.1 **Develop a joint funding strategy for the Delta Science Plan**

Develop a joint funding strategy for the Delta Science Plan involving federal and State regulatory agencies and other Delta Plan implementers. The joint funding strategy will be circulated for stakeholder, public, and Delta ISB review prior to being submitted to the Delta Stewardship Council for discussion and endorsement.

Primary Responsibility: Delta Stewardship Council, Delta Science Program

Action Participants: Federal and State agency directors, Delta Stewardship Council staff, stakeholders, Delta ISB, and public

5.2 **Adequately staff the Delta Science Program**

Staff the Delta Science Program adequately with new staff to ensure Delta Science Plan implementation.

Primary Responsibility: Delta Stewardship Council, Delta Science Program

Action Participants: State legislature and Governor's office

5.3 **Supplement the Delta Science Program with rotators**

Supplement the Delta Science Program core staff with rotators from other entities and develop funding and contracting mechanisms to cover the salary and benefits of the rotator.

Primary Responsibility: Delta Science Program

Action Participants: 'Rotators' – scientists from other federal, State, and local government, universities, stakeholders, and NGOs

5.4 **Implement and sustain the science infrastructure**

Implement and sustain the science infrastructure described in Chapter 4, through multiple funding sources.

Primary Responsibility: Delta Science Program

Action Participants: The legislature, tax- and rate-payers, particularly those that rely on the Delta for water, food, economic benefit, etc. All employers of scientists and engineers contributing to California achieving the coequal goals.

Summary of Actions

ACTION NUMBER	SHORT TITLE	ACTION LANGUAGE	PRIMARY RESPONSIBILITY	ACTION PARTICIPANTS	ACTION TYPE[14]	PRIORITY[15]
CHAPTER 2: ORGANIZING SCIENCE TO INFORM POLICY AND MANAGEMENT						
2.1	Establish a Policy-Science Forum	Establish a Policy-Science Forum where directors of federal and State agencies and science leaders gather around key issues (e.g., drought, introduction of native species) to: a) communicate grand challenges; b) explore issues directly with leaders of the scientific community for scientists to fully understand the science needed to support decisions and how that science can be best used; c) communicating best available science to support decision-making; and d) recommend workgroups as needed to collaboratively analyze policy alternatives and advise adaptive management of policies and programs [Appendix B].	Delta Science Program	Federal and State agencies directors, Lead/Chief Scientists with responsibilities in the Delta, relevant science leaders identified by the Lead Scientist (i.e., the IEP Lead Scientist, BDCP Science Manager, leading academic researchers, and agency research program directors), Science Steering Committee, stakeholders	New	Immediate
2.2	Develop, implement, and update a Science Action Agenda	Develop, implement, and update a Science Action Agenda (Ch. 1) through an inclusive process that organizes, integrates, and prioritizes science activities across programs to address decision-makers' grand challenges in an efficient manner [Appendix C].	Delta Science Program, Science Steering Committee, and agency directors	IEP, BDCP, ERP, CWQMC, SFCWA and other science programs of federal, State, and local agencies	New	Immediate

[14] Actions are classified as: a) new, b) ongoing, or, c) enhanced.
[15] The priority categories are defined as: a) Immediate – within the first year of Science Plan implementation; b) Near term – within years 2-5; and c) Longer-term – Beyond the first five years of Delta Science Plan implementation.

ACTION NUMBER	SHORT TITLE	ACTION LANGUAGE	PRIMARY RESPONSIBILITY	ACTION PARTICIPANTS	ACTION TYPE[14]	PRIORITY[15]
2.3	Sustain a web-based tracking system of science activities	Refine and expand existing efforts to develop and sustain a web-based tracking system to inventory and track research projects, monitoring, modeling, data management, synthesis, peer review, and other science activities to improve the transparency of science activities in the Delta.	Delta Science Program	IEP, BDCP, ERP, CWQMC, SFCWA, SRCSD, and other science programs of federal, State, and local agencies	New	Near-term
2.4	Establish a Science Steering Committee	Establish a Science Steering Committee that guides and advises science efforts to address current and anticipated grand challenges and inform decision-making through: 1) Translating the grand challenges articulated at the Policy-Science Forum into specific research priorities and actionable questions, 2) Providing high-level guidance and prioritization of science actions to be addressed in the Action Agenda (e.g., research topics), 3) Recommending topics for focused science synthesis efforts (including requests for proposals), 4) Providing guidance to science experts writing *SBDS* 5) Conducting science synthesis in sub-groups, and 6) Representing the *One Delta, One Science*-Community at Policy-Science Forums [Appendix D]	Delta Science Program	Delta Lead Scientist, Policy-Science Forum participants, individual scientists with relevant expertise (Delta scientists)	New	Immediate
2.5	Enable and identify resources for focused science synthesis	Enable and identify resources for focused science synthesis teams that distill the state of knowledge on specific topics (e.g., what is the role of ammonia/ammonium within the Delta ecosystem?). Focused science synthesis teams will address directed action and independently form a response to request for proposals (RFPs) for interdisciplinary synthesis activities.	Delta Science Program	Science Steering Committee, Delta Lead Scientist, scientists, science programs of federal, State, and local agencies	Enhanced	Near-term

ACTION NUMBER	SHORT TITLE	ACTION LANGUAGE	PRIMARY RESPONSIBILITY	ACTION PARTICIPANTS	ACTION TYPE[14]	PRIORITY[15]
2.6	Publish and update *The State of Bay-Delta Science*	Publish and update *The State of Bay-Delta Science* at least once every four years, aligned with the Biennial Bay-Delta Science Conference (offset from development of the Action Agenda) to regularly update and communicate the state of knowledge about the Delta system [Appendix E].	Delta Science Program, Delta Lead Scientist	Relevant experts, the Science Steering Committee	Enhanced	Near-term
2.7	Deliver annual state-of-Delta science address	The Delta Lead Scientist, in consultation with Delta scientists, will deliver an annual review of Delta science. Depending on the point in the four-year cycle of science, the presentation will highlight the Science Action Agenda, *The State of Bay-Delta Science,* and key questions, findings and innovations. This address will occur at a suitable venue and will be webcast and archived on the Delta Stewardship Council webpage.	Delta Science Program, Delta Lead Scientist	Relevant experts, the Science Steering Committee	New	Immediate
2.8	Develop and report performance measures	Measures and metrics will be developed to evaluate Delta Science Plan performance [Appendix A]. Parameters will be tracked that capture the development and impacts of the proposed science infrastructure, the role of science in guiding adaptive management, the use of best available science, and the effectiveness of the organization of science in guiding future refinements of the Delta Science Plan. Performance monitoring will be conducted and will include surveys and selected interviews with representatives of all the contributors, users and beneficiaries of the Delta Science Plan.	Delta Science Program, Delta Lead Scientist	Relevant experts, the Science Steering Committee, and independent third parties	New	Near-term

ACTION NUMBER	SHORT TITLE	ACTION LANGUAGE	PRIMARY RESPONSIBILITY	ACTION PARTICIPANTS	ACTION TYPE[14]	PRIORITY[15]
CHAPTER 3: ADAPTIVE MANAGEMENT FOR A COMPLEX SYSTEM						
3.1	Provide Adaptive Management Liaisons	Establish a team of Delta Science Program staff members with expertise in the science needed to advise those engaged in adaptive management. These staff members will provide advice on availability of models, regional monitoring activities, and relevant research as well as integrating individual adaptive management projects, plans, and programs across the Delta system. These staff members will serve as Adaptive Management Liaisons to their counterparts in agencies and organizations that are planning and implementing effective adaptive management programs and projects including Delta Plan covered actions [Appendix G].	Delta Science Program	Delta Science Program staff, agencies, and organizations involved in planning and implementing adaptive management	Enhanced	Immediate

ACTION NUMBER	SHORT TITLE	ACTION LANGUAGE	PRIMARY RESPONSIBILITY	ACTION PARTICIPANTS	ACTION TYPE[14]	PRIORITY[15]
3.2	Develop and use Adaptive Management Frameworks	Develop and utilize science-based adaptive management frameworks (Box 3-2) for restoration efforts and water management actions that are consistent with the Delta Plan's adaptive management framework and provide for consistent and integrated regional and system-wide approaches (Box 3-3). 1) The *Restoration Framework* will provide principles for adaptive management of Delta ecosystem restoration actions and will call for developing regional conservation strategies for each of the six priority habitat restoration areas[9]. The Restoration Framework will be developed by the participants in the Delta Conservancy's Delta Restoration Network. 2) A *Water Management Framework* will provide for adaptive management The Delta Science Program will work with ongoing management effort, such as the Long-term Operations Biological Opinions RPA Implementation and the Collaborative Adaptive Management Team (CSAMP/CAMT) to develop the Water Management Framework.	Delta Science Program and Delta Stewardship Council Planning along with (1) Delta Conservancy and its Restoration Network participants; (2) NMFS, USFWS, CDFW, DWR, USBR and other CSAMP/CAMT participants	Agencies and organizations involved in planning and implementing adaptive management	New	Near-term

[9] The Delta Plan identifies six priority habitat restoration areas: Yolo Bypass, Cache Slough Complex, Cosumnes River – Mokelumne River Confluence, Lower San Joaquin River Floodplain, Suisun Marsh, Western Delta/Eastern Contra Costa County.

ACTION NUMBER	SHORT TITLE	ACTION LANGUAGE	PRIMARY RESPONSIBILITY	ACTION PARTICIPANTS	ACTION TYPE[14]	PRIORITY[15]
3.3	Model future scenarios	Model alternative future scenarios and predict system-wide responses using interdisciplinary teams. Alternative scenarios will be developed and explored across the entire Delta, including the six priority restoration areas, and will address the categories of science described in Box 3-5. This will allow finite resources such as water, tidal energy, and sites suitable for restoration of certain ecological functions and a landscape-scale mosaic of habitats to be modeled, thereby identifying opportunities and tradeoffs to inform decisions on ecosystem restoration and water management actions.	Delta Science Program	Agencies and organizations that are planning and implementing adaptive management, CWEMF	Enhanced	Longer-term
3.4	Hold an annual Adaptive Management Forum	Hold an annual Adaptive Management Forum with national and international experts and local proponents to provide adaptive management training to build capacity for planning and implementing adaptive management, establish and refine adaptive management frameworks (Action 3.2), share lessons learned from the Delta and elsewhere, and provide a venue in which ecosystem restoration and water management adaptive management activities can be integrated.	Delta Science Program	National and international experts on adaptive management; federal, State and local agencies, non-governmental organizations, private organizations and academic institutions involved in implementing adaptive management	New	Near-term

ACTION NUMBER	SHORT TITLE	ACTION LANGUAGE	PRIMARY RESPONSIBILITY	ACTION PARTICIPANTS	ACTION TYPE[14]	PRIORITY[15]
CHAPTER 4: BUILDING THE INFRASTRUCTURE FOR SCIENCE						
4.1	Support Research	**Competitive Research Grants -** The Delta Science Program will manage and provide independent scientific peer review for a jointly-funded solicitation process for selecting research projects. Proposals will be assessed on intellectual merit (provided by anonymous external reviewers and review panels) and their potential contribution to the body of scientific knowledge needed to make management decisions. Proposal funding partners will make funding decisions based on their program priorities. **Delta Science Fellows** - The Delta Science Program and California Sea Grant will jointly manage an annual Delta Science Fellows solicitation with potential research topics and funding invited from other organizations. The selection will be based on intellectual merit (provided by anonymous independent peer review and science review panels) and contributions to the body of scientific knowledge needed to make Delta ecosystem restoration and water management decisions. **Rapid-response Research Grants** - To maintain flexibility and responsiveness of Delta science, some research funds will be set aside for opportunistic research and/or to address unexpected events such as a major flood, earthquake, levee failure, or salt-water intrusion into the Delta. These time-sensitive, innovative, or exploratory research ideas will be managed similar to the National Science Foundation's Rapid Response Research (RAPID) or Early-concept Grants for Exploratory Research (EAGER) grants. They will be funded through: a) focused solicitations where the scope of a project is generally known but it is open for proposals, or b) directed actions where the scope of the project is well-defined and the appropriate project team has been identified for example, due to ongoing activities.	Delta Science Program	IEP, BDCP, ERP, SFCWA and other science programs of federal, State, and local agencies, and NGOs	Enhanced	Near-term

ACTION NUMBER	SHORT TITLE	ACTION LANGUAGE	PRIMARY RESPONSIBILITY	ACTION PARTICIPANTS	ACTION TYPE[14]	PRIORITY[15]
4.2.1	Support and sustain a web-based information system for monitoring activities	Make monitoring information more accessible by supporting and sustaining a web-based information system, such as the Central Valley Monitoring Directory, that describes monitoring activities in the Delta, their products, and nexus to regulatory requirements and management actions.	CWQMC, IEP	Delta Science Program, statewide, regional, and local monitoring programs	Enhanced	Longer-term
4.2.2	Build a comprehensive Delta monitoring strategy and program	Build a Delta monitoring program with a shared purpose and strategy for integrated monitoring to systematically inform adaptive management and report on Delta environmental changes to policymakers and the public.	Delta Science Program	Delta Regional Monitoring Steering Committee, IEP, CWQMC,BDCP, and federal, State, and local agencies, NGOs	New	Longer-term
4.3.1	Host a data summit	Host a data summit to explore and identify needed improvements to cyber-infrastructure, data management capacity, and mechanisms to facilitate active data sharing, data mining, and analysis. Information generated in the Summit will inform the Science Action Agenda, support innovations in data integration and management, and develop paths for enhancing and sustaining current initiatives.	Delta Science Program, CWQMC, California Technology Agency, and other key partners	Delta Conservancy, USGS, NMFS, BDCP, IEP, CAMT, and other agencies and programs responsible for managing environmental data related to the Delta, as well as representatives from universities, consultants, NGOs, and invited experts in the field of data management	New	Immediate

ACTION NUMBER	SHORT TITLE	ACTION LANGUAGE	PRIMARY RESPONSIBILITY	ACTION PARTICIPANTS	ACTION TYPE[14]	PRIORITY[15]
4.3.2	Develop guidelines for data sharing	Based on outcomes from the Summit, guidelines for data sharing will be developed including criteria for metadata and descriptions of existing or needed web services for enabling community data access, integration, visualization, and display.	Delta Science Program, CWQMC, California Technology Agency, and other key partners	Delta Conservancy, USGS, NMFS, BDCP, IEP, CAMT, and other agencies and programs responsible for managing environmental data related to the Delta, as well as representatives from universities, consultants, NGOs, and invited experts in the field of data management	New	Near-term
4.4.1	Develop a collaborative community modeling framework	Develop a framework for collaborative community modeling (Box 4-3) to enhance interdisciplinary modeling, accelerate new understanding, avoid duplication of efforts, and support diverse modeling approaches. This framework will be based around the four science needs shown in Box 3-5 and will be developed through a Modeling Summit co-hosted by CWEMF and the Delta Science Program. At this summit, alternatives for managing and sustaining the framework will be explored and recommendations for the ecosystem of the Bay-Delta and its watershed will be made.	Coordination by Delta Science Program, with key roles for CWEMF (4.4.1 and 4.4.4) and ERP (4.4.2)	DWR, BDCP, CAMT, IEP, SWRCB, agencies, academics, consultants	Enhanced	Immediate
4.4.2	Develop, update, and maintain conceptual models	Develop, update, and maintain conceptual models to identify the current state of knowledge, identify gaps in understanding, contribute to the identification of research priorities, and support adaptive management planning and implementation. The Delta Science Program will track and help promote these conceptual models in guiding Delta management, including landscape-scale conceptual models for the six priority ecosystem restoration areas identified in the Delta Plan.	Coordination by Delta Science Program, with key roles for CWEMF (4.4.1 and 4.4.4) and ERP	DWR, BDCP, CAMT, IEP, SWRCB, agencies, academics, consultants	Enhanced	Near-term

ACTION NUMBER	SHORT TITLE	ACTION LANGUAGE	PRIMARY RESPONSIBILITY	ACTION PARTICIPANTS	ACTION TYPE[14]	PRIORITY[15]
4.4.3	Support high-priority model development	Support high-priority model development and refinement through research grants, fellowships, workshops, seminars, and conferences. Foster the development of inter-institutional and interdisciplinary clusters of scientists around model themes (as in the CASCaDE project). Ensure a continuity fo support for these initiaties to sustain model development and technical support to the broader scientific community.	Coordination by Delta Science Program, with key roles for CWEMF (4.4.1 and 4.4.4) and ERP (4.4.2)	DWR, BDCP, CAMT, IEP, SWRCB, agencies, academics, consultants	Enhanced	Immediate
4.4.4	Embrace alternative modeling approaches	Embrace alternative modeling approaches and support inter-model comparisons to help quantify uncertainty and sensitivity arising from different assumptions, quality and quantity of available data, different algorithms or alternative scenarios.	Coordination by Delta Science Program, with key roles for CWEMF (4.4.1 and 4.4.4) and ERP (4.4.2)	DWR, BDCP, CAMT, IEP, SWRCB, agencies, academics, consultants	Enhanced	Near-term

ACTION NUMBER	SHORT TITLE	ACTION LANGUAGE	PRIMARY RESPONSIBILITY	ACTION PARTICIPANTS	ACTION TYPE[14]	PRIORITY[15]
4.5.1	Foster integrative synthetic thinking throughout the Delta science and management communities	Provide forums and collaborative initiatives (e.g., Policy-Science Forum (Action 2.1) and focused science synthesis (Action 2.5)) as training and information exchange opportunities for science and engineering staff within regulatory and management agencies. These opportunities will allow staff to be integrative and develop “system-thinking” such that they become accustomed to habitually considering the larger context and linkages that go beyond the statutory boundaries of their respective agencies. This can be achieved via a combination of: 1) Actions described in Chapter 2 that are characteristic of “boundary organizations” that operate in both scientific and practical spheres (e.g., Delta Science Program, Public Policy Institute of California; Sustainable Conservation; SFEI-ASC, Pt. Blue Conservation Science), and that facilitate communication between scientists and decision-makers 2) Embedding research scientists within regulatory or resource management agencies to help fill high-priority knowledge gaps 3) Strengthening links through formal agreements, as listed in Action 4.1, between resource managers and scientists at research-focused institutions (e.g., Science Fellows) 4) Train resource management professionals directly via workshops, seminars, conferences, fellowships, and limited-term “rotator” positions with the Delta Science Program (see Chapter 5) to enable them to operate in both spheres of decision-making and science.	Delta Science Program	IEP; BDCP; SWRCB; and other federal, State, and local agencies; academic institutions; California Sea Grant	New	Near-term

ACTION NUMBER	SHORT TITLE	ACTION LANGUAGE	PRIMARY RESPONSIBILITY	ACTION PARTICIPANTS	ACTION TYPE[14]	PRIORITY[15]
4.5.2	Establish mechanisms and protocols for ongoing synthesis	Establish mechanisms and protocols for conducting ongoing syntheses to accelerate understanding of the Delta, to manage scientific conflict through shared processes, and to support policy and management decisions. Four mechanisms are: 1) Invited white papers/journal articles by small groups of authors 2) Expert workshop panels similar to the CALFED Science Program Ammonia/Ammonium Workshop [Appendix H] 3) Delta Collaborative Analysis and Synthesis (DCAS) – Focused teams with regional and national interdisciplinary experts that conduct in-depth analyses over a period of one year resulting in peer-reviewed journal articles or white papers that summarize current knowledge or bring fresh perspectives to a major issue 4) *The State of Bay-Delta Science* updates.	Delta Science Program	IEP; BDCP; SWRCB; and other federal, State, and local agencies	Enhanced	Immediate
4.6.1	Seek broad support and use of a standard process for conducting scientific peer review	Seek broad support and use of a well-defined, transparent, and widely accepted process for conducting scientific peer review that is consistent across programs and can be applied to research, planning, and management documents in the Delta.	Delta Science Program	Federal, State, and local agencies; NGOs, stakeholders, and universities	Enhanced	Immediate

ACTION NUMBER	SHORT TITLE	ACTION LANGUAGE	PRIMARY RESPONSIBILITY	ACTION PARTICIPANTS	ACTION TYPE[14]	PRIORITY[15]
4.6.2	Develop a response mechanism to scientific peer review	Develop a response mechanism to scientific peer review of programs, reports or actions that address each major point in the review, how the concern is being addressed, and the reasons for not being able to address any issue.	Delta Science Program	Federal, State, and local agencies; NGOs, stakeholders	Enhanced	Near-term
4.7.1	Develop and implement a communicatio n strategy	Develop and implement a broad-based communication strategy that makes use of a range of media and communications tools [Appendix J].	Delta Science Program	Communication experts, IEP, BDCP, Ecosystem Restoration Program, CWQMC and its workgroups, SFCWA, and other science programs of federal, State, and local agencies, State legislature	New	Near-term
4.7.2	Develop and maintain a new website	Develop a website that will be the central location for Delta science on the Internet. The best scientific and educational information that is available will be aggregated and organized making it accessible to scientists, policymakers, the general public, and grades K-12.	Delta Science Program	Web developer, IEP, BDCP, Ecosystem Restoration Program, CWQMC and its workgroups, SFCWA, and other science programs of federal, State, and local agencies, State legislature	New	Longer-term

ACTION NUMBER	SHORT TITLE	ACTION LANGUAGE	PRIMARY RESPONSIBILITY	ACTION PARTICIPANTS	ACTION TYPE[14]	PRIORITY[15]
CHAPTER 5: RESOURCES TO IMPLEMENT THE DELTA SCIENCE PLAN						
5.1	Develop a joint funding strategy for the Delta Science Plan	Develop a joint funding strategy for the Delta Science Plan involving federal and State regulatory agencies and other Delta Plan implementers. The joint funding strategy will be circulated for stakeholder, public, and Delta ISB review prior to being submitted to the Delta Stewardship Council for discussion and endorsement.	Delta Stewardship Council, Delta Science Program	Federal and State agency directors, Delta Stewardship Council staff, stakeholders, Delta ISB, and public	Enhanced	Immediate
5.2	Adequately staff the Delta Science Program	Staff the Delta Science Program adequately with new staff to ensure Delta Science Plan implementation.	Delta Stewardship Council, Delta Science Program	State legislature and Governor's office	New	Near-term
5.3	Supplement the Delta Science Program with rotators	Supplement the Delta Science Program core staff with rotators from other entities and develop funding and contracting mechanisms to cover the salary and benefits of the rotator.	Delta Science Program	'Rotators' – scientists from other federal, State, and local government, universities, stakeholders, and NGOs	Enhanced	Near-term
5.4	Implement and sustain the science infrastructure	Implement and sustain the science infrastructure described in Chapter 4, through multiple funding sources.	Delta Science Program	The legislature, tax- and rate-payers, particularly those that rely on the Delta for water, food, economic benefit, etc. All employers of scientists and engineers contributing to California achieving the coequal goals	Enhanced	Near-term

Glossary

Action participants - Agencies, other groups, and individuals involved in carrying out actions identified in the Delta Science Plan and Science Action Agenda.

Adaptive management liaisons - Delta Science Program staff members with expertise in the science supporting adaptive management to provide advice on availability of models, regional monitoring, relevant research, and integrating individual adaptive management projects, plans, and programs across the Delta system. These staff members serve as Adaptive Management Liaisons to their counterparts in agencies and organizations that are planning and implementing effective adaptive management programs and projects including Delta Plan covered actions.

Adaptive management - A framework and flexible decision-making process for ongoing knowledge acquisition, monitoring, and evaluation leading to continuous improvement in management planning and implementation of a project to achieve specified objectives.

Best available science - The best scientific information and data for informing management and policy decisions at a given point in time. Best available science shall be consistent with the guidelines and criteria found in Appendix 1A of the Delta Plan (2013).

Big data - Data sets so large, complex, or rapidly-generated that they cannot be processed by traditional information and communication technologies.[17]

Biological Opinion - A document stating the opinion of the U.S. Fish and Wildlife Service or the National Marine Fisheries Service as to whether or not federal action is likely to jeopardize the continued existence of a threatened or endangered species, or result in the destruction or adverse modification of critical habitat.

Broader impacts - Elements of a research project or proposal that affect societal needs or values beyond basic scientific or intellectual merit.

CASCaDE project - Computational Assessments of Scenarios of Change for the Delta Ecosystem is a research project to develop and apply a model-based approach of ecological forecasting to project future states of the Delta ecosystem, and to communicate the outcomes to resource managers. The objectives of this project are to develop and verify a set of models of climate, watershed hydrology, sediments, and water quality, and link these models to forecast how the Delta ecosystem will change.

Climate Change - Any significant change in measures of climate (such as temperature, precipitation, or wind) lasting for an extended period (decades or longer). Climate change may result from (1) natural factors, including changes in the sun's intensity or changes in the Earth's orbit around the sun, (2) natural processes within the climate system (such as changes in ocean circulation), or (3) human

[17] http://www.whitehouse.gov/blog/2013/04/18/unleashing-power-big-data

activities that change the composition of the atmosphere (for example, through burning fossil fuels) and land surfaces (for example, deforestation, reforestation, urbanization, and desertification).

Cloud computing - A model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction.[18]

Coequal goals - The two goals of providing a more reliable water supply for California and protecting, restoring, and enhancing the Delta ecosystem. The coequal goals shall be achieved in a manner that protects and enhances the unique cultural, recreational, natural resource, and agricultural values of the Delta as an evolving place.

Community model - An accessible, transparent, model shared among members of the Delta science community that is sustained by multiple sources and encapsulates the current knowledge of the Delta system.

Conceptual model - An explicit description of mental models, knowledge, and hypotheses about the structure and function of a system or process.

Consistency determination - See "Covered Actions and Delta Plan Consistency" in Chapter 2 of the Delta Plan.

Conveyance - The movement of water from one place to another. Conveyance infrastructure includes natural watercourses as well as canals, pipelines, and control structures including weirs. Examples of natural watercourses include streams, rivers, and groundwater aquifers. Conveyance facilities range in size from small, local, end-user distribution systems to large systems that deliver water to or drain areas covering multiple hydrologic regions. Conveyance facilities require associated infrastructure including pumping plants, power supply, diversion structures, fish ladders, and fish screens.

Covered action - A plan, program, or project that meets the statutory screening criteria defined in CA Water Code section 85057.5(a) and is determined to be subject to one or more of the regulatory provisions in the Delta Plan.

CSAMP/CAMT - The Collaborative Science and Adaptive Management Program and Collaborative Adaptive Management Team are groups formed to coordinate adaptive management pursuant to the remand of the National Marine Fisheries Service and United States Fish and Wildlife biological opinions for listed fish species in the Delta. Both groups are comprised of agency and stakeholder representatives.

CWEMF - The California Water and Environmental Modeling Forum is a non-profit, non-partisan organization whose mission is to increase the usefulness of models for analyzing California's water-related problems.

[18] http://www.info.apps.gov/content/what-cloud

Cyber-infrastructure - The coordinated aggregate of software, hardware, and other technological resources, as well as human expertise, required to support current and future discoveries in science and engineering.

Data mining tools - Software that uses sophisticated data search capabilities and statistical algorithms to discover patterns and correlations in large preexisting databases.[19]

Data streaming - Exchange of data between models.

Delta - The Sacramento-San Joaquin Delta as defined in CA Water Code Section 12220 and the Suisun Marsh, as defined in CA Public Resources Code Section 29101.

Delta Plan - The comprehensive, long-term management plan for the Delta to further the achievement of the coequal goals, as adopted by the Delta Stewardship Council in accordance with the Sacramento-San Joaquin Delta Reform Act of 2009.

Deterministic model - A model in which outcomes depend solely on starting and boundary conditions.

DRERIP (Delta Regional Ecosystem Restoration Implementation Plan) Evaluation - Procedure that uses conceptual models and a standardized process to document the evaluation by expert scientists of proposed ecosystem restoration actions.[20]

Ecosystem - A biotic community and its physical environment, considered as an integrated unit. Implied within this definition is the concept of a structural and functional whole unified through life processes. An ecosystem may be characterized as a viable unit of community and interactive habitat. Ecosystems are hierarchical and can be viewed as nested sets of open systems in which physical, chemical, and biological processes form interactive subsystems. Some ecosystems are microscopic, and the largest comprises the biosphere. Ecosystem restoration can be directed at different-sized ecosystems within the nested set, and many encompass multiple states, more localized watersheds, or a smaller complex of aquatic habitat.

Ecosystem Restoration - The application of ecological principles to restore a degraded or fragmented ecosystem and return it to a condition in which its biological and structural components achieve a close approximation of its natural potential, taking into consideration the physical changes that have occurred in the past and the future impact of climate change and sea-level rise (Water Code section 85066).

Ecosystem Restoration Program (ERP) - Multi-agency (California Department of Fish and Wildlife, NOAA Fisheries, U.S. Fish and Wildlife Service) effort aimed at improving and increasing aquatic and terrestrial habitats and ecological function in the Delta and its tributaries.[21]

Estuary - A place where fresh and salt water mix, such as a bay, salt marsh, or where a river enters an ocean.

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[19] http://wordnetweb.princeton.edu/perl/webwn?s=data%20mining
[20] http://www.dfg.ca.gov/erp/scientific_evaluation.asp
[21] http://www.dfg.ca.gov/erp/

Grand Challenges - large complex problems of importance to humankind, requiring numerous researchers, many years and appropriate resources to solve important national or global problems. A more complete definition is given in, *Grand Challenges in the Environmental Sciences* (National Research Council 2001).

Habitat Restoration - The manipulation of the physical, chemical, or biological characteristics of a site with the goal of returning the majority of natural functions to the lost or degraded native habitat.

Healthy ecosystem - An ecosystem with the capacity to provide environmental benefits including, but not limited to, protection of fish, wildlife, and plant communities, as well as societal benefits such as water quality and recreation opportunities.

Hydrodynamics - The description of the change in flow or motion of a liquid.

Hydrologic region - A geographical division of the State based on local hydrologic basins. The California Department of Water Resources divides California into 10 hydrologic regions, corresponding to the State's major water drainage basins: North Coast, San Francisco Bay, Central Coast, South Coast, Sacramento River, San Joaquin River, Tulare Lake, North Lahontan, South Lahontan, and Colorado River.

Independent scientific review - Assessment of a scientific or management product or program by scientists with appropriate expertise and no personal or institutional stake in the outcome of the review.

Interoperability standards - Standards that allow data to be exchanged and used.

Invasive Species - An alien species whose introduction causes or is likely to cause economic or environmental harm or harm to human health.

Linked Models - Sets of models in which outputs from one model are inputs to another model.

Mercury Methylation - Conversion of mercury by bacteria into a highly toxic form known as methylmercury that readily accumulates in the food chain .

Metadata – Information describing the origin and manner of collection of a set of data. This may include information such as time, location, citation of methods, quality control measures used, and estimates of accuracy and precision.

Model - An abstract simplification of the real world that formalizes hypotheses and current scientific understanding about how the modeled system works.[22]

Monitoring - Ongoing sampling, analysis, measurement, and survey activities used by scientists and managers to assess status and trends of natural resources in the Delta system.

Numerical Model - A model implemented in a computing language to understand the properties of a set of mathematical equations representing the behavior of a real-world system.

[22] http://archive.deltacouncil.ca.gov/delta_science_program/publications/sci_news_1211_models.html

Pelagic Organism Decline (POD) - A steep decline leading to near-record low populations of four pelagic species in the San Francisco estuary—delta smelt, young striped bass, longfin smelt, and threadfin shad—widely recognized as a serious issue by 2004.

Peer Review - The scientific process of subjecting research proposals or products, or management programs to assessment by independent scientific experts.

Performance Measures - A quantitative or qualitative tool to assess progress toward an outcome or goal.

Policy-Science Forum - A forum comprised of federal and State agency directors, the Delta Plan Implementation Committee, and leading scientists in the Delta system that will meet at least annually in public to identify and communicate grand challenges, strengthen the policy-science interface, and advise adaptive management of policies and programs.

Primary productivity - Process by which organisms make their own food from inorganic sources.[23]

Protection or protecting - Preventing harm to the ecosystem, which could include preventing the conversion of existing habitat, the degradation of water quality, irretrievable conversion of lands suitable for restoration, or the spread of invasive nonnative species.

Regional self-reliance - The degree to which a region implements water management options so that it can provide for all of its needs for water from within its own borders.

Regional water supplies - Water supplies that are found or developed within a region to be used within its own borders.

Restoration or restoring - Has the same meaning as in CA Water Code Section 85066. Restoration actions may include restoring interconnected habitats within the Delta and its watershed, restoring more natural Delta flows, or improving ecosystem water quality.

Rotators - Scientists from other organizations including federal agencies, State agencies, local government, universities, stakeholders, and non-governmental organizations who may spend a fixed term within the Delta Science Program to help meet the responsibilities of the Delta Science Program.

Science Action Agenda - A document produced by the Delta Science Program in cooperation with the science community that prioritizes near-term actions to inform management actions and achieve the objectives of the Delta Science Plan.

Science community - The group of scientists, including federal, State, and local agencies, academics, and the interested public, actively participating in scientific and management activities in the Delta.

[23] http://serc.carleton.edu/microbelife/research_methods/biogeochemical/productivity.html

Science Steering Committee - A group of non-partisan science experts selected by the Delta Lead Scientist that guide and advise science to address current and anticipated grand challenges and inform decision-making.

Science work plans - The set of near-term research activities and priorities carried out by the science program associated with an agency or other entity.

Simulation Model - A model that attempts to predict or understand the behavior of a system by emulating the interactions of its components.

Stakeholder - One who has a share or an interest, as in an enterprise.
Synthesis - The combining of often diverse information from multiple sources into one concept, model, or report.

The State of Bay-Delta Science - A summary and synthesis of the current state of scientific knowledge for the Delta, focused on the grand challenges of policymakers. *The State of Bay-Delta Science* was first published in 2008 by the CALFED Science Program, and will be updated by the Delta Science Program every four years.

Water demand - An economic principle that describes consumer desire and willingness to pay a price for a specific amount of water. Holding all other factors constant, the price of a good or service increases as its demand increases and vice versa.

Water export - The amount of water that a hydrologic region transfers to another hydrologic region.

Watershed - The land area that drains into a stream. The watershed for a major river may encompass a number of smaller watersheds.

Water Supply Reliability - See text box in Chapter 3 of the Delta Plan, “What Does It Mean to Achieve the Goal of a More Reliable Water Supply for California?”

Web services – Reusable and interoperable software components that can be accessed and integrated over the internet.

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APPENDIX A: Performance measures

Performance Measures can operate at very different levels of specificity to inform individual actions or overarching goals achievements. The Delta Independent Science Board recommended that a few high-level measures that can be used capable of to evaluate and improve the next version of the Delta Science Plan be developed during the first year of Plan implementation. More specific detailed performance measures will be developed in association with the Science Action Agenda.

Development of performance metrics to measure the performance of the Delta Science Plan will require careful consideration, utilization of existing tools, and potentially the development of new tools (e.g., web-based tracking systems, data integration efforts, and others as described in the Delta Science Plan). Primary objectives and desired outcomes of prioritized actions will need to be clearly defined in order to track progress over varying time scales and levels of complexity, and may include utilizing the SMART process below:

Specific: Clear definitions and exact expectations with standard data collection and reporting to accurately judge performance.

Measurable: Quantitative terms and numeric targets to meet performance expectations.

Accountable: Requires reasonable targets and time frames.

Results-Oriented: Must support core values or benefits - quantifies intermediate or final outcomes easily linked to other program goals or quantitative metrics.

Time-bound: Must function at reasonable time steps.

Examples of this approach include:

- Tracking web traffic statistics (e.g., such as Google Analytics) to determine how frequently science synthesis products, outreach materials, and data are downloaded. This approach is direct and allows for both summary and change-over- time analyses.

- Developing and distributing online surveys to track stakeholder and science community opinions and understanding of (a) the Delta Science Plan and its implementation (or resulting products), and (b) adaptive management and best available science. This approach will provide valuable information characterizing individuals and the broader community and help guide the refinement of science synthesis and outreach activities to achieve common understanding of uncertainties and jointly outline the potential outcomes of a range of experimental actions.

- A positive outcome of Science Plan implementation could be demonstrated through a simple numeric indicator tracking the number of lawsuits filed based on scientific ambiguity or disagreement.

Examples of this approach include, con't:

- The use of Delta Science Plan products in policy documents, public and legal hearings, and broad communication Bay-Delta activities will illustrate the impact of adaptive management (Chapter 3), science synthesis (Chapters 2 and 4.5) and outreach activities (Chapter 4.6).

APPENDIX B: Policy-Science Forum

Objective

Facilitate two-way interactions between policy and science communities for:

a) Communicating grand challenges

b) Exploring policy issues directly with leaders of the scientific community for scientists to fully understand the science needed to support decisions and for policymakers to understand how that science can be best used

c) Communicating best available science to support decision-making;

d) Recommend workgroups as needed to collaboratively analyze policy alternatives and advise adaptive management of policies and programs

Participants

- Leaders from federal and State government institutions (e.g., directors of agencies)
- Leading scientists working on Delta issues
- Relevant science leaders identified by the Delta Lead Scientist (i.e., the IEP Lead Scientist, BDCP Science Manager, Leading Academic Researchers, Sacramento County Regional Sanitation District's Chief Scientist and Research Program Directors)
- Subset of Science Steering Committee Members
- Interested public, through public comment at open meetings

Leadership

- Co-chaired by a rotating policy participant (Agency Director) and the Delta Lead Scientist
- Executive Committee – A small rotating executive committee will be identified from the larger Policy-Science Forum and include no more than six individuals. Composition of this committee will rotate. Roles and responsibilities include:
    - Setting the agenda for Policy-Science Forum meetings
    - Documenting the shared grand challenges identified by the policy community and the communication of high-level science to address the grand challenges
    - Ensuring other outcomes of the forum are documented
- Facilitated by the Delta Science Program

Meetings

- Forum meetings will occur at least once every year in a public setting, potentially associated with biennial science conferences or a science–focused meeting of the Interagency Implementation Committee
- Policy-Science Forum meetings will occur in public with opportunities for public comments

Potential Products

Potential products include a summary document (i.e., memo) or a short report of shared grand challenges identified by the policy community and the communication of high-level scientific understanding that addresses past or ongoing grand challenges. The Delta Science Program will publicly post any products resulting from the Policy-Science Forum and/or its executive committee.

APPENDIX C: Process for developing and updating the Science Action Agenda

Science Action Agenda content

The Action Agenda will contain prioritized science activities for addressing decision-makers' grand challenges and other management issues on a four-year cycle. The Action Agenda will include multiple-directed science activities and open competitive solicitations. It will include activities to predict potential outcomes of various management and intervention options, often referred to as "alternative futures." The Action Agenda will support coordinated and transparent adaptive management. It will retain flexibility to conduct science around unanticipated specific events such as a flood, earthquake, levee failure, salt-water intrusion into the Delta, major releases of hazardous materials, or unforeseen declines in Delta species.

Identifying and prioritizing science activities

The Action Agenda will be developed and updated through an open process by the Delta science community (including federal and State agencies, local agencies, academics, and interested public) and the Science Steering Committee (Action 2.4) under the leadership of the Delta Science Program. The Policy-Science Forum (Action 2.1) will provide high-level guidance for the Action Agenda through the identification of decision-makers' grand challenges and other management issues including statements about major problems, goals, and objectives. The Science Steering Committee will translate the grand challenges and other management issues into science questions to be addressed through priority science activities. These science questions will be used to guide the development and updates to the Action Agenda. Priorities for science actions identified at summits (i.e., the adaptive management forum (Action 3.1) and through collaborative efforts for developing community tools (i.e., data management (Action 4.3.1.) and shared models (Action 4.4.1.)) will also be incorporated into the list of prioritized science activities. Input from agencies, the science community and interested public on priority science activities will be gathered through forums such as the Annual IEP/CWEMF Workshop, State of the Estuary Conference, Delta Stewardship Council meetings, and the Biennial Bay-Delta Science Conference, as well as through written public comments.

The Science Steering Committee is responsible for applying scientific criteria (i.e., scientific likelihood to achieve its objective) to prioritize science activities to address the grand challenges and other high priority management issues. The Delta Science Program will use the prioritized list of science activities to assemble the Action Agenda. The Delta Lead Scientist has the responsibility for articulating the rationale for the Action Agenda and prioritizing the actions.

Review Process

The Action Agenda will be reviewed by the Delta Independent Science Board, consistent with its responsibility to provide oversight of the scientific research, monitoring, and assessment programs that support adaptive management of the Delta.

Use

The Action Agenda will be the shared science priority actions for the Delta. It will provide the overarching agenda and direction for developing and updating individual science programs' work plans. The Delta Science Program and agency directors will coordinate the implementation of the Action Agenda through an open process that connects agencies and interested parties to collectively fund priority actions. Collective implementation of the Action Agenda will build the knowledge base and science tools necessary to address decision-makers' needs. New knowledge gained through implementation of the Action Agenda will inform updates to *The State of Bay-Delta Science* as well as the Action Agenda.

Updating the Action Agenda

The four-year cycle of the Action Agenda will be aligned with the Biennial Bay-Delta Science Conference so that the update of one or the other will occur every two years to maximize opportunities for openly engaging the science community, policymakers, managers, and interested public. Discussions on and releases of Action Agenda updates will be timed to gather input through the Annual IEP Workshop, State of the Estuary Conference, Delta Stewardship Council meetings, and the Biennial Bay-Delta Science Conference. The four-year cycle was selected in order to alternate the use of the Biennial Bay-Delta Science Conference to gather input and rolling out major publications of *The State of Bay-Delta Science* [Appendix E]. The Action Agenda may be updated more regularly in response to major changes in the Delta (e.g., major flood or invasion of non-native species) that require science support.

Box C-1 Interim Science Action Agenda

To initiate implementation of the Delta Science Plan, an Interim Science Action Agenda will be completed in 2014. It will include a list of priority science actions and questions from existing documents (see below) and collaboration with other agencies and programs that produce and utilize scientific information. The process for developing the Interim Science Action Agenda is an expedited and scaled-back version of the process described in this appendix. The Interim Science Action Agenda will include near-term priority science questions and needs from existing agency and program plans and documents, synthesis and review panel reports, Delta ISB memos, and more. It will not include a comprehensive analysis of current applied research, monitoring, data exchange, and modeling efforts that are relevant to the grand challenges of the Delta (Chapter 2) and will be limited to interim actions to be addressed within a two-year time frame.

Example sources of priority science actions include:

1. Delta Plan
2. *The State of Bay-Delta Science 2008*
3. Bay Delta Conservation Plan
4. Ecosystem Restoration Program Conservation Strategy
5. IEP Work Plans and Proposal Solicitations
6. Delta Science Program and Ecosystem Restoration Program PSPs
7. Independent Review Panel Reports
8. Workshop and Synthesis Documents (e.g., SWRCB Delta Flow Objective Workshops)
9. Monitoring Plans and Proposals (e.g., Delta Regional Monitoring Program: A Proposal for a Regional Monitoring and Assessment Framework and its Implementation)
10. CAMT Science Questions and Work Plans

APPENDIX D: Science Steering Committee

Objective

Build capacity and sustain collaborative processes for ongoing science research and synthesis to develop shared scientific understanding.

Charge to the Science Steering Committee

Guide and advise science to address current and anticipated grand challenges and inform decision-making through:

1) Translating the grand challenges articulated at the Policy-Science Forum into specific research priorities and actionable questions
2) Recommending topics for focused science synthesis efforts (including requests for proposals)
3) Providing high-level guidance and prioritization of science actions to be addressed in the Action Agenda (e.g., research topics)
4) Providing guidance to science experts writing *SBDS*
5) Conducting science synthesis in sub-groups, and
6) Representing the *One Delta, One Science* Community at Policy-Science Forums

Committee Composition

The Science Steering Committee will be comprised of no more than 12 interdisciplinary science experts. Committee members will be selected by the Delta Lead Scientist based on their scientific expertise and merits rather than as representatives of agencies, institutions or interest groups, similar to the requirements of the National Academies of Science for composing balanced committees without significant conflict of interest or biases[24]. Criteria for participation on the committee may include:

- Relevant scientific expertise
- Outstanding scientific credentials
- Awareness of Delta policy and management issues
- The ability to think synthetically about the Delta system and translate grand challenges into science questions and priority science activities

To ensure non-partisan participation by individual members and address any questions of committee composition for balance and conflict of interest, individuals being selected to serve and serving on the committee will be required to submit background information regarding any potential conflicts of interest to the Delta Lead Scientist. The Delta Lead Scientist will evaluate the committee composition on an annual basis to ensure its balance of expertise can adequately guide science to address current and anticipated grand challenges.

[24] http://www.nationalacademies.org/xpedio/groups/nasite/documents/webpage/na_069688.pdf

Leadership

The Science Steering Committee will be facilitated by the Delta Science Program under the leadership of the Delta Lead Scientist.

A subset of the Science Steering Committee will represent the community of Delta scientists at Policy-Science Forum meetings.

Potential products

Products will be posted publicly by the Delta Science Program on its website. Public input and recommendations on these products will be facilitated by the Delta Science Program. Products could include:

- Science questions and preliminary priority topics for the Science Action Agenda
- Prioritized science activities for the Science Action Agenda
- Recommended topics for focused science synthesis directed actions and RFPs
- Science synthesis products produced by sub-groups of the Science Steering Committee
- Guidance and direction for revising and updating *SBDS*

APPENDIX E: *The State of Bay-Delta Science*

Objective

Regularly summarize and communicate current scientific knowledge to inform policy and management decisions and associated grand challenges. This includes progress made on key research questions and the identification of knowledge gaps.

Content and Use

The State of Bay-Delta Science (SBDS) is a summary synthesis report of the latest scientific understanding of the Delta. It includes science information that is distilled and presented in a manner that can be used to support policy and management decisions. *SBDS* will be used to inform the Policy-Science Forum and to guide updates to the Action Agenda. It will also be a foundational component of the Delta Lead Scientist's delivery of the Annual State-of-Delta Science Address.

Production Timeline

The State of Bay-Delta Science, 2008 will be updated by the end of 2014. Thereafter, it will be published at least once every four years with periodic online updates as new knowledge becomes available. The four-year production cycle of *SBDS* will be aligned with the Biennial Bay-Delta Science Conference (offset from development of the Science Action Agenda). During production years, public gatherings of the Delta science community (i.e., the Biennial Bay-Delta Science Conference, Annual IEP Workshop, other synthetic workshops such as CABA, and State of the Estuary Conference) will be used to gather additional broad input on the topics addressed in *SBDS.*

Authors and Publishers

The State of Bay-Delta Science will be written by relevant science experts with guidance from the Science Steering Committee. The Delta Science Program will be responsible for publishing *SBDS*.

Review Process

The State of Bay-Delta Science will be reviewed by the Delta Independent Science Board.

APPENDIX F: Ecosystem restoration at Prospect Island and Yolo Ranch - DRERIP Evaluation

Prospect Island and Yolo Ranch are individual restoration initiatives in the Delta identified to satisfy biological opinion requirements for delta smelt and salmon habitat. Historically, the process of planning and implementing habitat restoration in the Delta and Suisun Marsh has been long and unsatisfactory. Obtaining clarity on project objectives, understanding landscape potential, managing property, acquiring permits, and making scientific observations are among the challenges the agencies and other involved parties face.

In developing the Delta Regional Ecosystem Restoration Plan (DRERIP), the Ecosystem Restoration Program commissioned a suite of conceptual models about Delta ecosystem processes, habitats, stressors and life history of key fish species, and created a scientific evaluation process for restoration projects. The purpose of the DRERIP scientific evaluation process was to evaluate restoration project designs based on the best available scientific understanding on a variety of issues, utilizing the DRERIP conceptual models. The evaluation process engages the conceptual model authors and other recognized experts to consider the effects of restoration design alternatives on such issues as mercury methylation potential, aquatic vegetation recruitment and establishment, primary productivity, creation of salmonid and delta smelt habitat, predation, and changes in regional hydrodynamics. The evaluation process will generate an emerging consensus on the range of management actions that might achieve desired outcomes, while keeping in mind both risks to investments and those associated with unintended consequences. The up-to-date scientific information is then vetted with managers who consider it in formulating their implementation designs. This scientific evaluation process was conducted recently for the Prospect Island restoration project as part of the Fish Restoration Program Agreement process.

Given the scale of planned ecosystem restoration, the process for evaluating projects must be much more adept and swift than it has been in the past. The Prospect Island and Yolo Ranch evaluations have been instructive both because design improvements emerged from the discussion, and the dynamics of the group deliberations illustrate how complex restoration actions can be effectively carried out. While the design evaluations were somewhat different, several important lessons were learned. First, the evaluations demonstrated the value of historical ecological assessment. The landscape position of the projects and broader regional physical and biological context provide essential clues about landscape ecological potential. Second, significant hydrodynamics and transport modeling was completed prior to the evaluation about such metrics as current structure, water exposure time, and regional tidal range effects. Modelers were in the room and were able to demonstrate concepts in real time that elevated the group understanding of key processes. Third, landscape changes will initiate a complex and non-linear cascade of processes and outcome trajectories that are difficult to predict with certainty. There was a deep recognition that the projects will affect, and be affected by, the regional ecosystem, especially as it changes in the future from climate change and additional restoration. Finally, many participants agreed that the evaluation process would be improved if a regional landscape conceptual model had been incorporated from the beginning with advance insights about the sensitivity of tidal energy, currents, turbidity, and fish-habitat behavior (to name a few) to landscape changes. The designs of both projects were changed based on this scientific evaluation.

APPENDIX G: Delta Science Program Adaptive Management Liaisons (Action 3.1)

The Delta Reform Act and Delta Plan require the use of an adaptive management framework to improve the planning, implementation, and evaluation of restoration projects and water management actions. The Delta Science Program will make available adaptive management liaisons for early consultation on adaptive management for Delta Plan proposed covered actions. Early consultation for covered actions will assist project proponents to obtain consistency determinations and increase the likelihood that the best alternative for implementation is chosen to advance program, plan, and system-wide goals and objectives.

Proponents of actions that do not require consistency determinations under the Delta Plan may also benefit from the advice of Delta Science Program staff prior to the implementation phase of a project or plan, especially those that have the potential to: (1) substantially advance the coequal goals; (2) add to the knowledge base and reduce uncertainties related to achieving performance measures in the Delta Plan; and (3) likely reduce other significant barriers to large-scale restoration or water management improvements, such as regulatory constraints.

There are several advantages of early involvement by Delta Science Program staff in non-covered actions and those that are outside of the Council's geographic jurisdiction but could have significant direct or indirect benefits to Delta ecosystem functions or decrease reliance on water exports from the Delta. They may include:

- ✓ Increased competitiveness in future grant applications for Integrated Regional Water Management projects, the Carbon Cap-and-Trade Auction Investment fund, and other sources
- ✓ Savings in staff time for project proponents resulting from information on regional monitoring and other activities, advice on conceptual models, and assistance in networking with other programs
- ✓ A greater degree of accountability and transparency via broadly applicable performance measures via a standardized approach to the use of science across agencies and programs

APPENDIX H: Delta Science Program draft policies and procedures for independent science workshops (August 2013)

Background

As part of its mission to provide the best available scientific information to guide management and inform policy making in the Bay-Delta system, the Delta Science Program (DSP) promotes and provides independent synthesis of the state of scientific knowledge on topics of importance to decision-makers. The typical purpose of a workshop is to obtain a synthesis of the scientific information on an important topic with major management or policy implications based on published papers, reports, and other information, including professional judgment and experience, in a short period of time. The policies and procedures below describe how science workshops provided by the Delta Science Program will be conducted.

Decision to Hold a Workshop

A science workshop may be requested by any agency or other interested party. The workshop will focus the scientific information related to an important topic with management or policy implications. The Delta Science Program's decision to conduct a workshop will depend on other (competing) commitments of the Delta Science Program and the relevance of the workshop with respect to the goals and objectives of it and the Delta Stewardship Council. Furthermore, the Delta Science Program will only agree to conduct a workshop if there is sufficient funding available, if there is sufficient time available to complete the workshop and deliver a report, and if there is sufficient scientific information to justify a workshop. The ultimate decision to conduct a workshop rests with the Lead Scientist for the Delta Science Program.

Planning Meetings

Meetings to plan for a workshop may be held with members of the requesting party and interested agency/stakeholder representatives prior to initiation of the workshop. Participants in a Workshop Planning Group composed of those parties may communicate their expectations for the pending workshop, will provide input on the Charge to the Panel, may consider the workshop agenda and panel-member composition, and may provide pertinent background documents or other instructional scientific materials for the workshop through the Delta Science Program.

Charge to the Panel

Charge questions are developed with input from the Workshop Planning Group. The Lead Scientist has the final authority for the Charge to the Panel. Charge questions will be technical (or analytical) in nature, and will not include policy prescriptions (however, it is recognized that responses and other information in a workshop report may be used in future decision-making by resource managers and policymakers.) Accordingly, charge questions will be crafted to best draw applicable guidance, but not to solicit explicit policy recommendations or prescriptions.

The scope of the Charge to the Panel will include background information (including the legal, regulatory, and management background necessary to set the full policy context for the Charge to the

Panel), questions and tasks for the panel, a description of the role of the panel and rules for its deliberation and the form and scope of the workshop product, and a timeline of deliverables.

Independent Science Workshop Panel

Panels will include no fewer than five members. The Lead Scientist has the final authority for the selection of Independent Science Workshop Panel members and will consider input from the Workshop Planning Group. The selection of panelists will consider an individual's standing in the scientific community, expertise in disciplinary areas, and with technical skills relevant to the documents, presentations, and technical issues to be evaluated in the workshop, and absence of a demonstrated conflict of interest. A panel as a whole is expected to have a broad range of expertise including some familiarity with the geographic region, physical processes, policy issues, ecosystems, and species-specific aspects of the workshop topic.

Workshop Materials

Materials to be provided to the Independent Science Workshop Panel include scientific literature relevant to the workshop topic and pertinent background materials. Workshop materials may also include a preliminary synthesis report prepared by or under the direction of Delta Science Program staff. Background materials will not be limited to the specific technical questions and issues in the Charge to the Panel, but can include documents describing the legal and regulatory context of the workshop questions and tasks, and consider the management implications of materials provided to the workshop panel and relevant to the workshop report. Other study materials or information identified as pertinent to the workshop introduced by panel members during the panel meeting can be used at the discretion of the panel. Panels are encouraged to request any additional information or other materials that might facilitate their deliberations and report production. Stakeholders and other interested parties may submit materials to be considered by the workshop panel; however, final decisions relating to any materials to be provided to the panel rest with the Lead Scientist.

Workshop Presentations

In addition to the written materials provided to the panel prior to the workshop, scientific presentations will be conducted as part of the public component of the workshop. As with written materials, presentations may provide necessary background and regulatory context, but most presentations will focus on recent and ongoing scientific research, synthetic efforts by local experts, and scientifically-based expert opinion. Stakeholders and other interested parties may propose topics and presenters to address the panel; however, final decisions related to any presentations rest with the Lead Scientist.

Communication with the Panel

No direct communications by interested parties (including the agency or party that requested the workshop) with panel members on issues pertinent to the workshop should be made without the knowledge and consent of the Delta Science Program. The panel may be asked to disregard any communication received without the knowledge and consent of the Delta Science Program.

Public Meetings

The workshop process will be open and transparent to the extent practicable. Unless there are compelling reasons to do otherwise, each independent scientific workshop will have a public meeting. While the workshop panel will deliberate on camera to develop their recommendations, the opportunity for public comment will be provided as a part of any open (public) sessions of each workshop.

Public Communication

A webpage accessible through the Delta Stewardship Council and Delta Science Program website will present background information on each Independent Science Workshop, meeting agendas, membership of panels convened, all background materials and presentations, and the final panel document. To the extent possible, all materials for panel will be posted on the website at the same time that they are provided to the panel; at a minimum, 10 days in advance of the first public meeting of the workshop panel. Scheduling and other information about that meeting and the availability of workshop report(s) will be sent to the Delta Stewardship Council's list serve.

The Delta Science Program will compile and retain a record of the workshop, including the materials described above as well as any additional materials provided to the panel including presentations from the public sessions of meetings.

Panel Report(s)

The Delta Science Program may suggest grammatical or formatting edits of a draft report to improve it, but will not otherwise substantively amend a workshop panel report. The content, substance, and recommendations of a workshop panel report are those of the panel, not the Delta Science Program or Delta Stewardship Council. The Delta Science Program will post the report after approval of the panel. The Delta Science Program may provide a courtesy copy of the report to the agency or party that requested the workshop in advance of posting the report. If the agency that requested the workshop chooses to develop a written response, the response will be posted along with the report at the time it becomes available.

APPENDIX I: Delta Science Program draft policy and procedures for independent scientific review (February 2013)

Background

As part of its mission to provide the best available scientific information to guide management and inform policy making in the Bay-Delta system, the Delta Science Program promotes and provides independent scientific review of processes, programs, plans, and products. The policies and procedures below describe how independent scientific review provided by the Delta Science Program will be conducted.

Decision to Provide Review

Independent scientific review may be requested by any agency or other interested party. The review will focus on one or more written documents. The Delta Science Program's decision to provide a review will depend on other (competing) commitments of the Delta Science Program and the relevance of the review with respect to the goals and objectives of it and the Delta Stewardship Council. Furthermore, the Delta Science Program will only agree to provide a review if there is sufficient funding available for the review, if there is sufficient time available to complete the review and deliver a report, if the opposite document is complete and ready for review[25]. The ultimate decision to provide a review rests with the Lead Scientist for the Delta Science Program.

Planning Meetings

Meetings to plan for a review may be held with members of the requesting party, authors of the document(s) subject to review, and interested agency/stakeholder representatives prior to initiation of the review. Participants in a Review Planning Group composed of those parties may communicate their expectations for the pending review, will provide input on the Charge to the Panel, may consider the review schedule and panel-member composition, and may provide pertinent background documents or other instructional materials for the review through the Delta Science Program.

Charge to the Panel

Charge questions are developed with input from the Review Planning Group. The Lead Scientist has the final authority for the Charge to the Panel. Charge questions will be technical (or analytical) in nature, and will not include policy prescriptions (however, it is recognized that responses and other information in a review report may be used in future decision-making by resource managers and policymakers.) Accordingly, charge questions and tasks will be crafted to best draw applicable guidance, but not to solicit explicit policy recommendations or prescriptions.

The scope of the Charge to the Panel will include background information (including the legal, regulatory, and management background necessary to set the full policy context for the Charge to the

[25] Review of draft documents, like final documents, is appropriate provided they are complete and ready for review. In contradistinction, review of partial documents, whether final or draft, is generally inappropriate.

Panel), questions and tasks for the panel, a description of the role of the panel and rules for its deliberations and the form and scope of the review product, and a schedule of deliverables.

Independent Science Review Panel

Panels will include no fewer than five members. The Lead Scientist has the final authority for the selection of Independent Scientific Review Panel members and will consider input from the Review Planning Group. The selection of panelists will consider an individual's standing in the scientific community, expertise in disciplinary areas and with technical skills relevant to the documents and technical issues subject to review, and absence of a demonstrated conflict of interest. A panel as a whole is expected to have a broad range of expertise including some familiarity with the geographic region, physical processes, policy issues, ecosystems, and species-specific aspects of the review.

Materials for Review

Materials to be reviewed by the Independent Scientific Review Panel include the review document or documents, and pertinent background materials. Background materials will not be limited to the (specific) technical questions and issues in the Charge to the Panel, but can include documents describing the legal and regulatory context of the review questions and tasks, and consider the management implications of materials provided to the review panel and relevant to the review report. Other study materials or information identified as pertinent to the review introduced by panel members during the panel meeting can be used at the discretion of the panel. Panels are encouraged to request any additional information or other materials that might facilitate their deliberations and report production. Stakeholders and other interested parties may submit materials to be considered by the review panel; however, final decisions relating to any materials to be provided to the review panel rest with the Lead Scientist.

Communication with the Panel

No direct communications by interested parties, including the agency that produced the document subject to review, with panel members on issues pertinent to the review during the review period should be made without the knowledge and consent of the Delta Science Program. The panel may be asked to disregard any communication received without the knowledge and consent of the Delta Science Program.

Public Meetings

The review process will be open and transparent to the extent practicable. Unless there are compelling reasons to do otherwise, each independent scientific review will have a public meeting. While the review panel will deliberate on camera to develop their recommendations, the opportunity for public comment will be provided as a part of any open (public) sessions of each review.

Public Communication

A webpage accessible through the Delta Stewardship Council and Delta Science Program website will present background information on each independent Scientific Review undertaken, meeting agendas, membership of panels convened, all background materials and documents to be reviewed, and the final review document. To the extent possible, all materials for panel review will be posted on the website at the same time that they are provided to the panel; at a minimum, 10 days in advance of the first meeting of the review panel. Scheduling and other information about that meeting and the availability of review report(s) will be sent to the Delta Stewardship Council's list serve.

The Delta Science Program will compile and retain a record of the review, including the materials described above as well as any additional materials provided to the panel including presentations from the public sessions of meetings.

Panel Report(s)

The Delta Science Program may suggest grammatical or formatting edits of a draft report to improve it, but will not otherwise substantively amend a review panel report. The content, substance, and recommendations of a review panel report are those of the review panel, not the Delta Science Program or Delta Stewardship Council. The Delta Science Program will post the report after approval of the panel. The Delta Science Program may provide a courtesy copy of the report to the agency that produced the materials subject to review in advance of posting the report. If the agency that produced the materials subject to review chooses to develop a written response, the response will be posted along with the review at the time it becomes available.

APPENDIX J: Communication

This is an initial outline of existing and new communication tools to be included in a comprehensive Delta science communication strategy.

1. Enhance existing communication tools

    - Continue support for the open access journal, *San Francisco Estuary and Watershed Science*, and expand its visibility within the community
    - Continue publication of the Delta Science Program's *Science News* and explore opportunities for joint publication with the San Francisco Estuary Partnership's *Estuary News*
    - Facilitate the transfer of information (research and monitoring designs and results, data, etc.) among scientists working in the Delta on a real-time basis using existing, expanded and/or future web portals
    - Continue support for existing scientific conferences including the biennial Bay-Delta Science Conference and the State of the Estuary Conference to discuss new research findings and explore new initiatives; invite the Policy-Science Forum to meet during the conferences, and convene media events around these gatherings
    - Expand the number of workshops and seminars currently being conducted including brown bag luncheon seminars and seminars hosted jointly with the UC Davis Center for Aquatic Biology and Aquaculture (CABA) which are open to the public and free of charge
    - Improve the existing Delta Science Program website and/or develop a new website that would be the repository for all Delta science on the internet integrating its functions with those of existing sites such as EcoAtlas, CWEMF, and the estuaries portal currently under development. The best scientific and educational information that is available will be aggregated and organized on this site making it available to scientists, policymakers, the general public, and those in grades K-12.

2. Develop new communication tools

    - Develop information sharing with other large water and ecosystem management programs in the U.S. and internationally
    - Include preparation of outreach materials summarizing recent scientific research results and findings specifically directed to policy- and decision-maker

Identify mechanisms that allow agency scientists to access peer reviewed scientific literature that is not available through online open access journals.